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Year 1 Field Work Report:
Utah Bat Monitoring Protocol

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INTRODUCTION

Many bat populations in North America are thought to be declining (Stebbings 1980, McCracken 1988, Richter et al.1993, Tudge 1994, Altingham 1996). The International Union for Conservation of Nature (IUCN) lists 10% of microchiroptera species (one of two suborders of bats that include those species that typically feed on insects and echolocate; all Utah bats are microchiroptera) as threatened (Mickleburgh et al. 2002). The combination of slow reproduction, natural rarity and genetic isolation make bats susceptible to population and range declines (Racey and Entwistle 2003). Of 45 bat species in the United States, six are listed as federally endangered and 19 are former candidates for listing (Code of Federal Regulations 1991; USFWS 2008). Of Utah's 18 species, six are Tier II Species of Concern in the Utah Comprehensive Wildlife Conservation Strategy (Utah's Wildlife Action Plan, UDWR 2005). These apparent declines in bat populations may be attributed, in part, to loss of suitable habitat due to increased human recreational activity (caving and climbing), mine closure programs, urbanization and the lack of information on population level trends (Humphrey and Kunz 1976; UDWR 2005). The status of bat population trends can be assessed through landscape level monitoring of bat species and communities (Weller 2008). Understanding landscape level population trends allows managers to detect population or range declines and take actions to stop or reverse those trends (Bat Conservation Trust 2004). Therefore, a long-term landscape level monitoring program is integral to the continued conservation of bat populations and communities (Racey and Entwistle 2003; Duchamp et al. 2007).

Landscape based models provide an estimate of bat community and species presence, and provide a useful bat conservation tool (Jaberg and Guisan 2001). Monitoring bats based on landscape-scale habitat features accounts for the broad scale influences of habitat on bat

abundance and species distribution (Jaberg and Guisan 2001, Duchamp et al. 2007, Duff and Morrell 2007). Landscape level bat monitoring programs have been developed across the United States, Canada, and the United Kingdom (Hendricks and Maxwell 2005; Arnett 2007; Ford et al. 2005; Nagorsen and Brigham 1993; Stebbings and Griffith 1986).

Recommendations from Other Recent Work

Studies in Montana, Oregon, Washington, California, West Virginia, and Hawaii indicate that occupancy based models provide a good estimate of bat species and community distribution. BATGRID in the Pacific Northwest created the first regional scale occupancy monitoring program and influenced the development of other monitoring programs in the western U.S. (Ormsbee 2008). In a Montana study, sample units were stratified by five USFS Ranger Districts (Hendricks and Maxwell 2005). They selected 5 sample units (10 x 10 km) within strata and surveyed each twice at different locations within the sample unit (Hendricks and Maxwell 2005). Hendricks and Maxwell recommended continued sampling stratified by ecoregion or Ranger District. Hendricks and Maxwell (2005) noted that the Oregon BATGRID provided a suitable monitoring program with protocol modifications. A landscape scale bat monitoring program in the Cascade Range of Oregon also used a presence/absence framework (Arnett 2007). Researchers on that project stratified sample units within three forest densities, placing12 sample units in each. A sample location consisted of a 4.8 km diameter survey site and a water source with surface area equal to or less than 20 x 20 m (400 m^2). In Oregon, bat species distributions were related to landscape level habitat factors such as elevation and roost density (Arnett 2007). A study in West Virginia was also based within a presence/absence framework (Ford et al. 2005). This study consisted of 63 sample sites surveyed with acoustic

techniques only. Ford et al. (2005) detected associations between landscape scale habitat variables and the occurrence of bat species and communities. Results from a pilot project in Hawaii, also based on the use of acoustic detectors only, indicated that reliable occupancy estimates were not attained until 15 sample units or visits per strata (Gorresen et al.2007). A multiple species monitoring study in Washington, Oregon and California was stratified by four forest and reserve conditions (old growth forest) (Weller 2008). Sample cells within condition were 5.5 km hexagonal cells. A total of 51 cells were sampled twice each in two locations >500 m apart resulting in a total of 204 sample units. Weller (2008) used a combination of acoustic and capture methods focused on small ponds or low gradient streams. He calculated detection probabilities for 8 species ranging between 0.24 (long-eared myotis) and 0.53 (California myotis), and occupancy estimates ranging from 0.59 (Yuma myotis) to 0.78 (California myotis). These estimates are the first for occupancy and detection of bats at a regional scale (Weller 2008). All of those studies used an occupancy based logistic regression analysis with presence absence data.

Hendricks and Maxwell (2005) found that improper use of equipment by poorly trained personnel resulted in underutilized acoustic data. They recommended significant training on devices prior to field use, standardization of net effort and multiple visits to all sample units. In addition, they found a positive curvilinear relationship, asymptote at 40-50 net-hours, between net-hours and number of species captured (see http://en.wikipedia.org/wiki/Asymptote). The full species list was obtained by a mean 2.6 hours of net set. In Arnett's (2007) study he observed that the small number of suitable ponds within sample units limited the findings of the study. Weller's research (2008) found that detection and occupancy estimates could be improved markedly by increasing sample visits per sample cell to six. He also noted that rare species may

not be detected at suitable levels ($p<0.15$) and thus could not be included in the covariate models. Weller also recommended that sampling sites within sample cells should be greater than 500 m apart.

In summary, studies such as these indicate that monitoring bats at a landscape level requires ecological stratification with at least 15 sample units per strata, and that using acoustic and mist netting methods in combination increased detection probabilities and the accuracy of occupancy estimates. The authors of these studies also recommended standardization of methods to increase detectability, including: sampling for 40-50 net-hours per site, net sets of at least 2.6 hours duration, and 6 sampling visits per sample cell.

Protocol Design

In consideration of the findings of previous research, we designed a two-level monitoring protocol that would specifically address Department of Defense (DoD) and the State of Utah management objectives regarding 1) landscape scale bat ecology issues and 2) statewide bat demographics. To address the former, we developed a landscape level bat monitoring protocol to meet DoD and Utah Division of Wildlife Resources (UDWR) bat management goals (SIKES ACT; UDWR 2005). We conducted a thorough review of refereed and government report-based literature pertaining to landscape level bat monitoring. We also utilized academic resources in Utah. Specifically, we consulted with the personnel listed below. The combination of literature review and expert consultation led to the creation of a Utah specific bat monitoring protocol.

1. Dr. John Bissonette, Utah State University, who has 40 years experience in design and implementation of landscape scale monitoring of vertebrates;

2. Dr. Frank Howe, UDWR and USU, an avian ecologist familiar the use of GIS generated Tessellated grids for wildlife monitoring and with 20 years experience with large scale monitoring of highly mobile organisms;
3. Dr. David Koons, a population ecologist at Utah State University (USU) experienced with occupancy model based data analysis;
4. Dr. Mary Conner, a population ecologist at USU specializing in metapopulation level monitoring and statistical rigor and suitability of occupancy model analysis;
5. Dr. Mike Wolfe, Utah State University, who has 30 years experience monitoring wildlife populations in Utah;
6. Dr. Kevin Bunnell, Utah Mammals Program Coordinator at UDWR, who provided a power analysis and management perspective; and
7. Dr. James MacMahon, former president of the Ecological Society of America, who consulted on overall project design and scientific rigor of the protocol.

Additionally, we developed an occupancy model based protocol designed to be carried out every three years across Utah to address statewide bat demographics. This three year approach was selected to deal with inevitable funding shortfalls and differing management priorities for agencies across the state. The protocol was designed with the realization that data collection cannot be supported annually on a statewide scale. These methods provided sufficient data and power to adequately assess the status of bats in Utah. The first year of the proposed monitoring protocol produced a simple occupancy model that can be used to determine the covariate relationships of species. This protocol maintained the proactive management of bat species in Utah created by the funding received by the DoD Legacy Program (07-346, 08-346 and 09-346). The model approach assumed: 1) Occupancy status does not change between

survey periods. While reproduction occurs across survey periods it should not affect species presence/absence just state (adult, sub-adult or juvenile); 2) Occupancy across sites can be modeled with covariates, thus environmental variables associated with bat occurrence were also collected, and 3) detection of species at sites is independent. The objective of this study was to estimate the detectability and occupancy of bat species across covariates in Utah. Overtime, these estimates should be able to detect significant changes in bat species populations, a very difficult and coveted piece of information to detect.

METHODS

This occupancy based monitoring protocol was stratified by 5 ecoregions: Colorado Plateau shrublands, Great Basin shrub steppe, Wasatch and Uinta montane forests, Mojave Desert and Wyoming Basin shrub steppe. A total 65, 20 x 20 km (hexagonal) sampling cells were randomly selected across these ecoregions. The State's three largest ecoregions (Colorado Plateau shrublands, Great Basin shrub steppe, Wasatch and Uinta montane forests) each harbored 20 sampling cells, while the limited size of the Mojave Desert and Wyoming Basin shrub steppe ecoregions allowed for placement of only two and three hexagons, respectively. To assure independence, all sampling cells were at least 20 km from the next nearest cell (that is, there are at least six unsampled cells surrounding each selected cell). This sampling design was based within the framework of Utah's existing Tessellated Grid, which serves as the monitoring base for many other species in the state.

Survey methodology included both bat capture using mist nets and remote acoustic recording of bat vocalizations. For the former, an observer selected water source within each sampling cell served as the focal point for setting mist nets (Fig. 1). Survey sites consisted of open water between 4 and 2250m^2 in size with a mean area of 319m^2 of open water. Water occurred on a slope of less than 4%. This size restriction was incorporated to improve detection probability and enable high net coverage per unit area. The smaller the netting area the more likely a species that is present will be detected (captured at the site). An acoustic survey was conducted simultaneously in the same cell, but at a distance greater than 500 m from the netting location. Analyses of the acoustic recordings are ongoing and will be discussed in future papers. Both types of bat survey were conducted in each of the survey cells in the three largest ecoregions a total of three times between May and September, resulting in a total of six sampling

visit for each cell. The three sampling periods were established to coincide with major bat demographic events: in-migration, parturition and pre-migration/volancy. In order to increase the probability of detecting rare species in the two smaller ecoregions (Mojave Desert and Wyoming Basin shrub steppe), sampling cells were double sampled during each period, resulting in a total 12 visits. Sampling periods provided an estimate of occupancy within sites, ecoregions and statewide as well as providing an estimation of detection probability and occupancy across time and space. At this stage in the project we created a base detectability and occupancy estimation across species at a state wide scale. We used program MARK® to create estimates for occupancy and detectability. We then used a sample site only based logistic regression analysis across all three sampling periods. We used PROCREG in the SAS® software system. The intent of this analysis is to provide a summary of this first year's data collection period. This analysis does not take into account the landscape scale interactions between detectability, occupancy and sampling cell characteristics.

Results of bat captures (mist netting) were recorded and compiled for occupancy modeling as described in Tables 2, 3 and 4 (Appendix VII). Each species observed at a sample site was assigned a value of "1." If a species was not observed it was assigned a "0" value. If a site was not visited in a sample period a "." was recorded for each species. Table 3 provides the basis for the covariate occupancy analysis and consists of three data types; location, survey site, and local habitat data. Location data provided a geo-reference for the site that can be used to create spatially explicit variable sets. Survey site data enabled a comparison of bat occupancy and survey site characteristics. And local habitat data provided a landscape level variable set that was used in covariate model construction. A description of each variable on the data sheet in Table 3 is provided in Table 4 (Appendix VII).

Capture Site Methods (Utah Bat Conservation Cooperative)

Monitoring visits consisted of setting mist nets from sunset to 0100h. Data was collected using the protocols developed by the Utah Bat Conservation Cooperative (UBCC). Bats are capable of recognizing and avoiding nets, therefore nets were set in locations and arrangements that enabled the highest possible capture rate. Placement was used to restrict flight corridors where the net covers the only way through. Nets were also set in configurations such that bats that avoided the one net may be captured in another. In Utah, surveys are generally most productive between June and mid-September. Therefore, sampling was concentrated during this period, though some sites in extreme southern portions of the state were sampled in May.

Generally, two people were used to run a mist net station. When a high capture rate was expected, we made sure an adequate number of trained personnel were available to efficiently run the station. Net poles, stakes, wading boots and any other equipment that had come in contact with water or mud was cleaned with a 10% bleach solution following use. Bat measuring equipment (dental picks, rulers, calipers, etc) and any other tools which came in direct contact with bats were cleaned with isopropyl alcohol. Those cleaning measures were instituted to reduce the threat of the spread of invasive aquatic organisms and bat borne diseases. See the Utah Bat Monitoring Protocol document for more information on netting and monitoring protocols.

The US Fish and Wildlife Service (FWS) and others have published decontamination guidelines for equipment due to the devastating impacts of white-nosed syndrome (WNS) on the East Coast. The UBCC recommends the adoption of one of these guidelines during bat surveys. The FWS guidelines can be found in Appendix IX and at

http://www.fws.gov/northeast/whitenose/FINALDisinfectionProtocolforBatFieldResearchJune2009.pdf. The Western Bat Working Group also has a set and can be found here: http://wbwg.org/conservation/whitenosesyndrome/WNSPreventionProtocol061509.pdf.

Several good WNS websites offer more information: http://wbwg.org/conservation/whitenosesyndrome/whitenose.html, http://www.fws.gov/northeast/wnsplanning.html, http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/, and http://www.caves.org/WNS/.

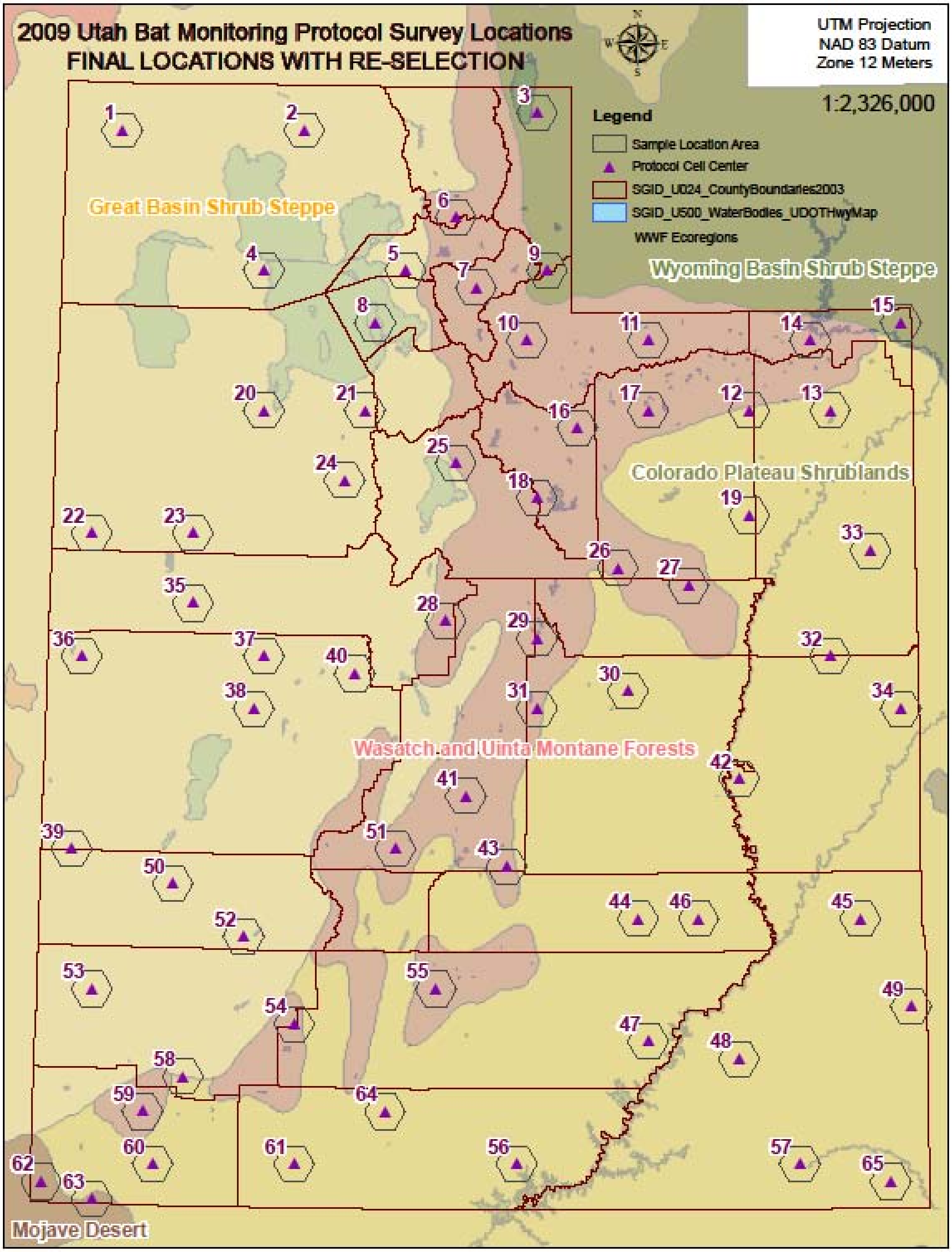


Figure 1. Map of sampling cells across Utah's five ecoregions. Sampling locations were randomly selected, 35% of sample cells were reselected to meet sample site parameters.

Table 1. Simulated presence/absence data for a single species within a single ecoregion across 20 survey sites. This will be the final data format prior to analysis with program MARK®.

	Ecoregion		
Site #	May	June	July
1	1	1	0
2	1	1	0
3	1	1	1
4	1	0	1
5	1	0	0
6	1	0	0
7	0	0	0
8	0	0	0
9	1	0	1
10	1	1	0
11	1	0	0
12	1	0	0
13	1	0	0
14	1	0	0
15	1	1	0
16	1	1	0
17	1	1	0
18	1	0	0
19	1	1	1
20	1	0	0

Table 2. Example data sheet (back page) for 18 bat species, code refers to the species code identifier.

Occupancy Summary					
Period (circle**) : 1a 1b 2a 2b 3a 3b**		**Site #**:			
Enter a "1" (presence) for each age and stage class for each species CAPTURED and "0" (absence) if the species was NOT captured.					
Enter "R" (at least 1 reproductive individual is captured within a species) or "NR" (no reproductive individuals within a species are captured).					
Each cell should contain a number (0 or 1) and a letter (R or NR)					
Common Name	**Code**	**Adult Male**	**Adult Female**	**Sub-adult Male**	**Sub-adult Female**
pallid bat	ANPA				
Townsend's Big-eared bat	COTO				
big brown bat	EPFU				
spotted bat	EUMA				
Allen's big-eared bat	IDPH				
western red bat	LABL				
hoary bat	LACI				
silver-haired bat	LANO				
California myotis	MYCA				
western small-footed myotis	MYCI				
long-eared myotis	MYEV				
little brown myotis	MYLU				
fringed myotis	MYTH				
long-legged myotis	MYVO				
Yuma myotis	MYYU				
big free-tailed bat	NYMA				
Canyon bat	PIHE				
Brazilian free-tailed bat	TABR				
GENERAL COMMENTS					

Table 3. Example Protocol Data sheet (front) for habitat assessment at bat capture and acoustic recording survey sites.

Utah Bat Occupancy Site Description Data Sheet

Legacy III Bat Monitoring Program

Survey Visit (circle one)**:** 1 2 3 **Survey Type** (circle one)**:** Acoustic or Capture

Survey Date:________________________ **Survey Time** (military)**:** Start ________ End ________

Moon Phase:

Site Location

Site #:________

Ecoregion:__________________________

Utm Coordinates: Datum Used (NAD 83 Preferred):________________ Utm N__________________ Utm E ________________

Elevation (m)**:**

Site Description

Water Source Type (circle one most appropriate)**:** Artificial: Earthen Tank, Guzzler, Trough, or Stock Tank N/A
Natural: Stream, Oxbow, Back Water, or Natural Spring N/A

Water Source Parameters (m)**:** Length: ________ Width: ________ Depth: ______ Perimeter:________

Obstruction of Surface Water (circle one)**:** Vegetation, Wire, or Other ________________

Other Taxa in Area (list species observed within 1 km)**:**

invertebrates ________________

birds ________________

fish ________________

mammals ________________

Human Disturbance Level (circle one in each category)**:** High, Medium, or Low

Timing of Disturbance: Continuous, Intermittent or Rare

Description of Disturbance: ________________

Local Habitat Description

Land Cover Type

Land Form: ________________

Soil Type: ________________

Canopy (circle one)**:** Forest, Woodland, Mountain Brush, Brush, Grass, or Invasive Forb

Understory (circle one)**:** Mountain Brush, Brush, Grass, Invasive Forb, or Bare Soil

Geology (circle one)**:** Igneous, Metamorphic, or Sedimentary

Adjacent Potential Roosts (within 10km)**:** Foliage, Tree, Crevice, Cave, Mine, Bridge, or Other

Distance to each from above (km):

Drawing of Net Set

^
N

Table 4. Explanations of field for the covariate data sheet (Tables 2 and 3). Other fields are shown in Appendix VIII.

<u>Site Location</u>

Ecoregion

World Wildlife Fund designated ecoregions (Colorado Plateau shrublands, Great Basin sagebrush steppe, Mojave Desert and the combined Wasatch and Uinta montane forest and Wyoming Basin shrub steppe).

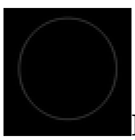
Site #

A unique identifier between 1 and 20 within each ecoregion.

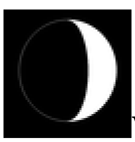
UTM

The Universal Transverse Mercator (**UTM**) coordinate system, X and Y values.

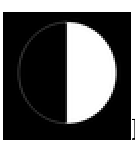
Moon Phase



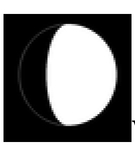
New Moon - The Moon's unilluminated side is facing the Earth. The Moon is not visible (except during a solar eclipse).



Waxing Crescent - The Moon appears to be partly but less than one-half illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.



First Quarter - One-half of the Moon appears to be illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.



Waxing Gibbous - The Moon appears to be more than one-half but not fully illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.

RESULTS

We captured 17 bat species during 205 discrete sampling events. A total of 57 site visits were made in the Colorado Plateau ecoregion, 58 in the Great Basin ecoregion, 60 in the Wasatch and Uinta montane forest ecoregion, 18 in the Wyoming Basin ecoregion and 12 in the Mojave Desert ecoregion. We estimated occupancy and detection probability for the 12 species that were detected in ≥ 18% of survey sites state wide. Five bat species were not detected above this 18% threshold. These were the Allen's big-eared bat, *Idionycteris phyllotis* (2%); big free-tailed bat, *Nyctinomops macrotis* (3%); spotted bat, *Euderma maculatum* (3%); Townsend's big-eared bat, *Corynorhinus townsendii* (14%); and Mexican free-tailed bat, *Tadarida brasiliensis* (9%). These five species were therefore not included in the analysis.

Statewide observed occupancy was consistently lower than estimated occupancy. Differences between observed and estimated occupancy were negatively related to detection probability (Table 5). Observed occupancy varied from 19% for the fringed myotis, (*Myotis thysanodes*) to 45% for the long-legged myotis (*Myotis volans*). Estimated occupancy ranged from 24% for the hoary bat to 59% for the little brown bat (*Myotis lucifugus*). Detection probability was highest for the canyon bat, *Pipistrellus hesperus* (64%) and lowest for the hoary bat, *Lasiurus cinereus* (22%) (Table 5). Akaike's Information Criterion (AIC) model accuracy varied across species and variable sets.

Table 5. Overall model averaged occupancy and detection probability for 12 species on a statewide scale.

Species	Species code	Observed Occupancy	Estimated Occupancy (ψ)	SE (ψ)	Detection probability (p)	SE (p)
Pallid Bat	ANPA	0.292	0.337	0.060	0.569	0.102
Big brown bat	EPFU	0.375	0.400	0.060	0.351	0.103
Hoary bat	LACI	0.203	0.236	0.063	0.222	0.140
Silver-haired bat	LANO	0.406	0.442	0.069	0.565	0.101
California myotis	MYCA	0.219	0.278	0.079	0.375	0.133
Western small-footed myotis	MYCI	0.328	0.436	0.099	0.359	0.109
Long-eared myotis	MYEV	0.406	0.496	0.087	0.420	0.100
Little brown bat	MYLU	0.344	0.593	0.173	0.250	0.097
Fringed myotis	MYTH	0.188	0.329	0.140	0.241	0.130
Long-legged myotis	MYVO	0.453	0.546	0.082	0.473	0.203
Yuma myotis	MYYU	0.281	0.440	0.129	0.284	0.111
Canyon bat	PIHE	0.297	0.311	0.061	0.636	0.113

The highest ranking model for the pallid bat, *Antrozous pallidus*, consisted of the interaction of 4 variables (Table 6). The pallid bat was strongly associated with the Colorado plateau shrublands and the Mojave Desert (Figure 2). Pallid bat occupancy was also correlated with the presence of an artificial ponded water source type, more southerly latitudes or portions of the state (UTM N) and elevations between 1700 and 1200m with a mean elevation of 1450m (Figure 3, 4 and 5).

Table 6. AIC model fit for pallid bats in Utah. K is the number of variables in the model. AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model consisted of Ecoregion, southerly distribution (UTM N), elevation and water source type (WSType).

Pallid Bat			
Model	K	AIC	ΔAIC
Ecoregion, UTMN, Elevation, Wstype	4	138.786	0
Ecoregion, UTMN, Elevation, Wstype, Canopy	5	139.115	0.329
Ecoregion, Elevation, Wstype	3	140.837	2.051
Elevation	1	164.097	25.311

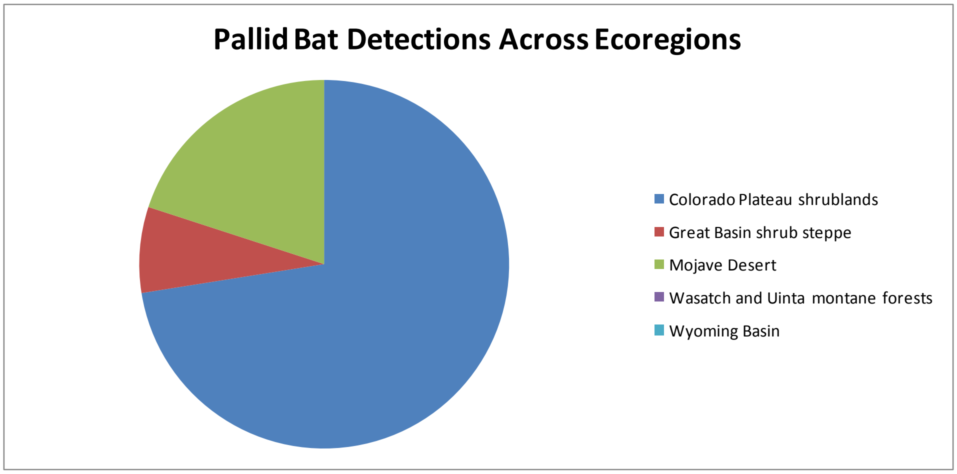


Figure 2. Pallid bat occurrences across Utah's five ecoregions.

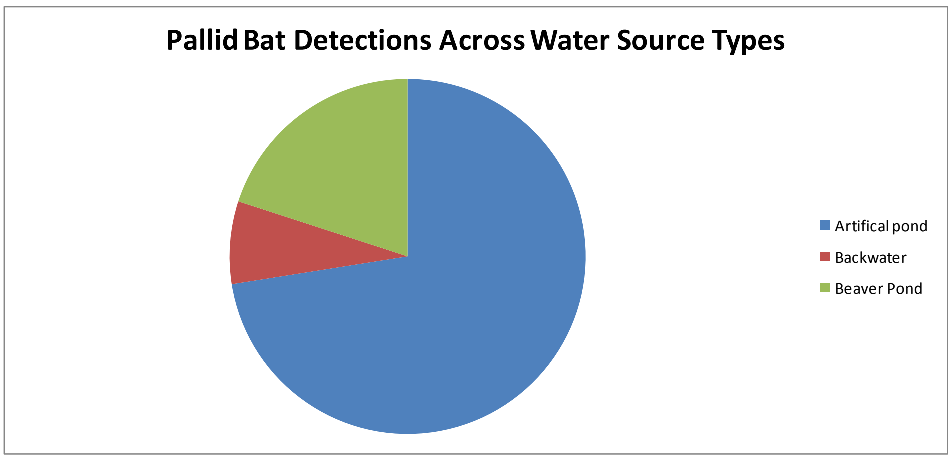


Figure 3. Pallid bat observations across water source types.

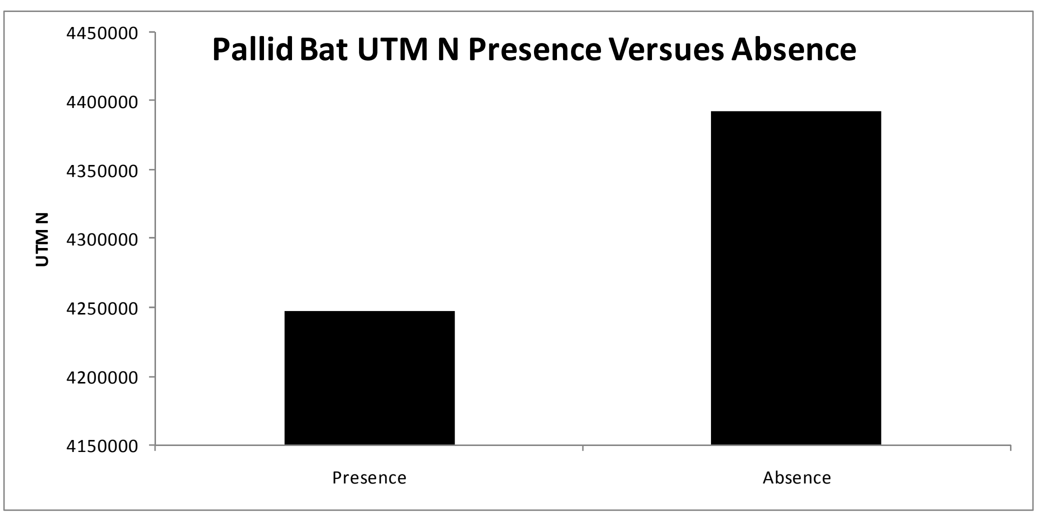


Figure 4. Mean UTM N for pallid bat presence event and absence events.

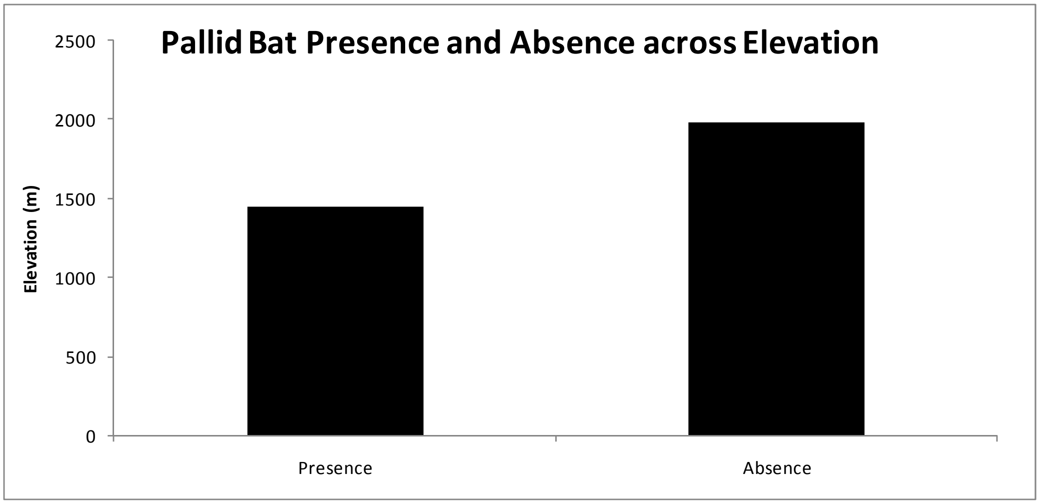


Figure 5. Mean elevations for pallid bat presence and absence events.

A single variable model based on canopy type best described big brown bat, *Eptesicus fuscus*, distribution (Table 7). Big brown bats were most closely correlated with a brush canopy type (fig. 6).

Table 7. AIC model fit for big brown bats in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model.

Big brown bat			
Model	K	AIC	ΔAIC
Canopy	1	232.073	0.000
Canopy, Disturbance Timing	2	232.717	0.644
Disturbance Timing	1	235.023	2.950

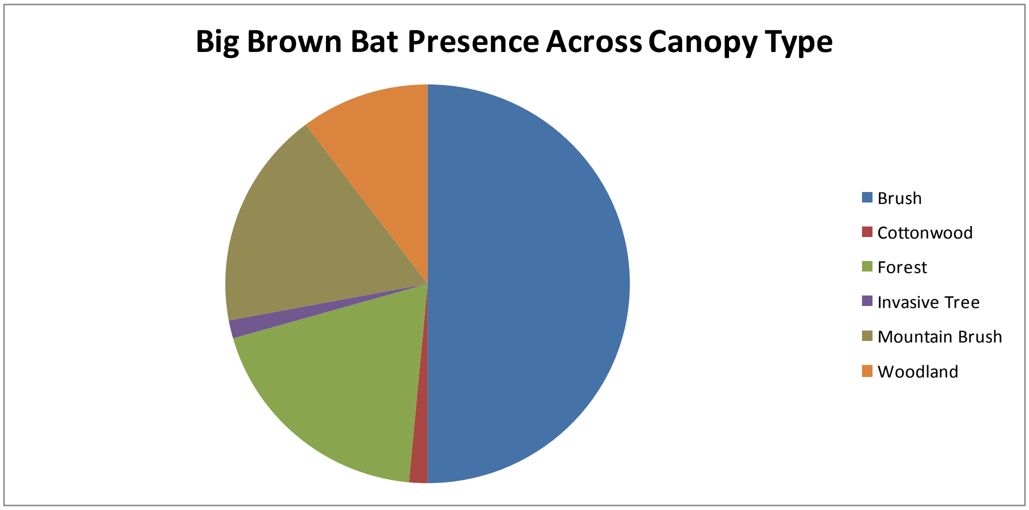


Figure 6. Big brown bat presence across canopy types.

The hoary bat best fit model consisted of a two variables (Table 8). The hoary bat was correlated with a northerly UTM (i.e. northern latitudes or portions of the state) (Figure 7). This species was also associated with a mean water source width between 1 and 31m and mean of 17m (Figure 8).

Table 8. AIC model fit for hoary bats in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. Water source width (Wswidth) and Northern location make up the best fit model.

Hoary bat			
Model	K	AIC	ΔAIC
UTMN Wswidth	2	140.56	0.000
UTMN	1	141.122	0.562
Ecoregion UTMN UTME NetArea Wswidth Wsarea	6	144.174	3.614
Wswidth	1	144.755	4.195

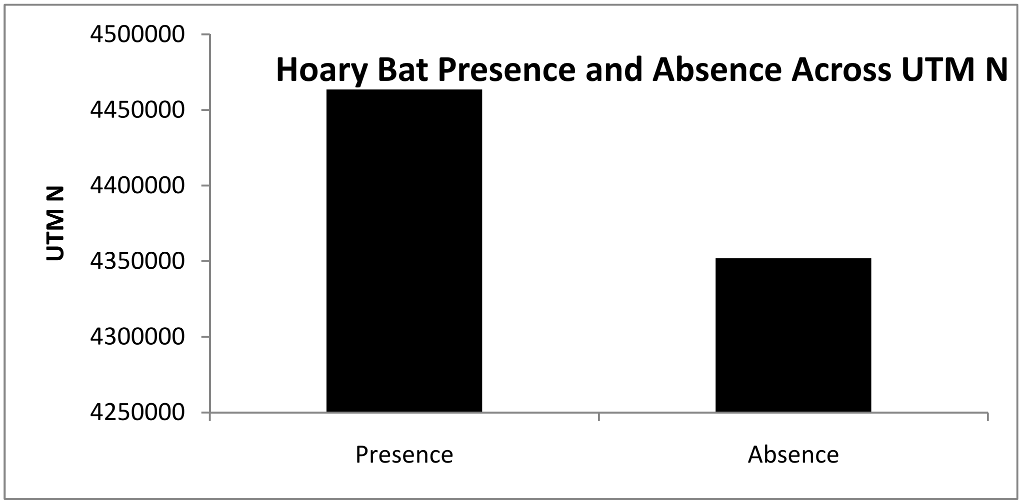


Figure 7. Mean UTM N for hoary bat presence and absence events.

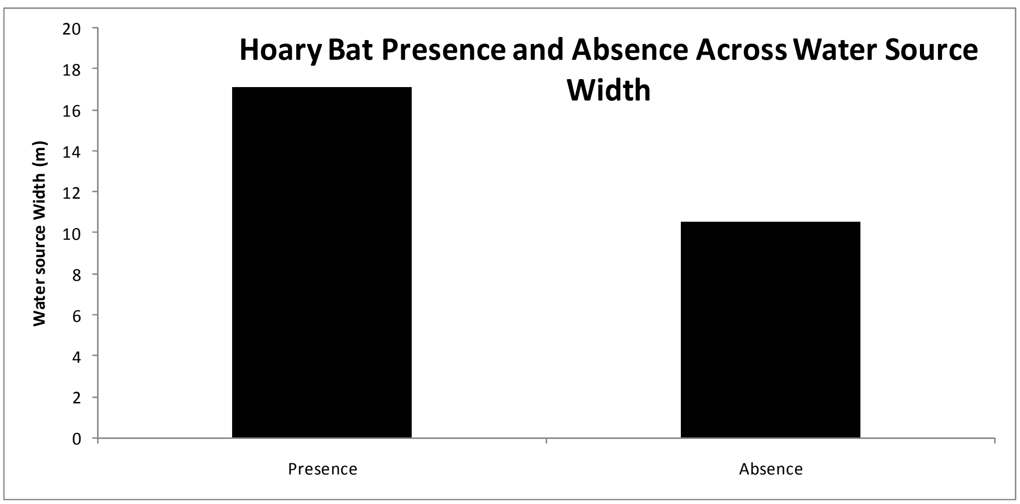


Figure 8. Mean water source width for hoary bat presence and absence events.

The presence of silver-haired bats, *Lasionyceris noctivagans*, was best described by a four variable model (Table 9). This species was correlated with a generally eastern UTM (i.e. eastern part of the state) (Figure 9). Silver-haired bats were also associated with elevation; 95% of observations occurred between 1700 and 2500m with a mean elevation above 2100m (Figure 10). Silver-haired bat observations were associated with a relatively low net effort specifically a

net area mean of $63m^2$ (Figure 11). This species was also associated with a water source width between 1 and 27m and a mean of 14m (Figure 12).

Table 9. AIC model fit for silver-haired bats in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. Best fit model consisted of Eastern location (UTM E), elevation, total net area used at capture sites (NetArea) and mean water source width at capture sites.

Silver-haired bat			
Model	K	AIC	ΔAIC
UTME Elevation NetArea WSWidth	4	207.15	0.000
Elevation NetArea WSWidth	3	210.53	3.38
UTME Elevation NetArea	3	215.74	8.59
Elevation	1	219.798	12.648

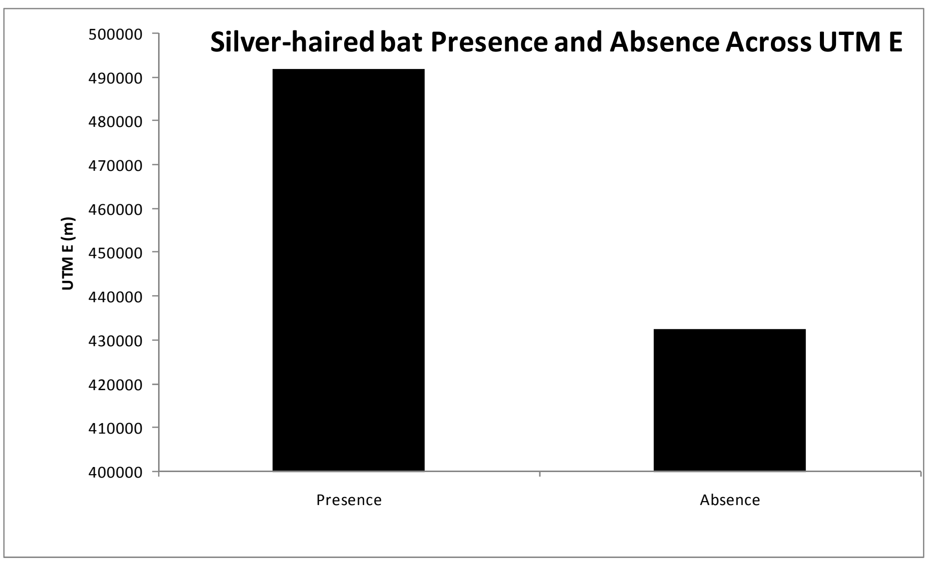


Figure 9. Mean UTM E for silver-haired bat presence and absence events.

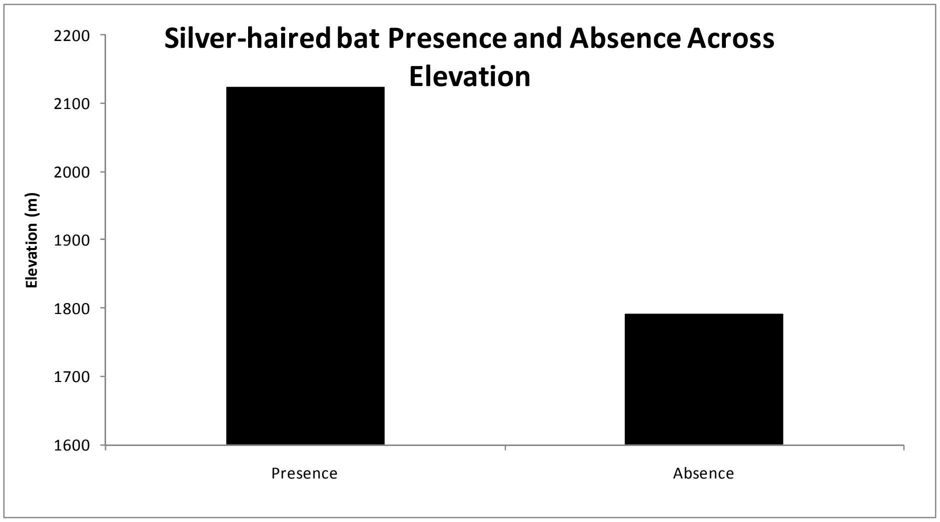


Figure 10. Mean elevation for silver-haired bat presence and absence events.

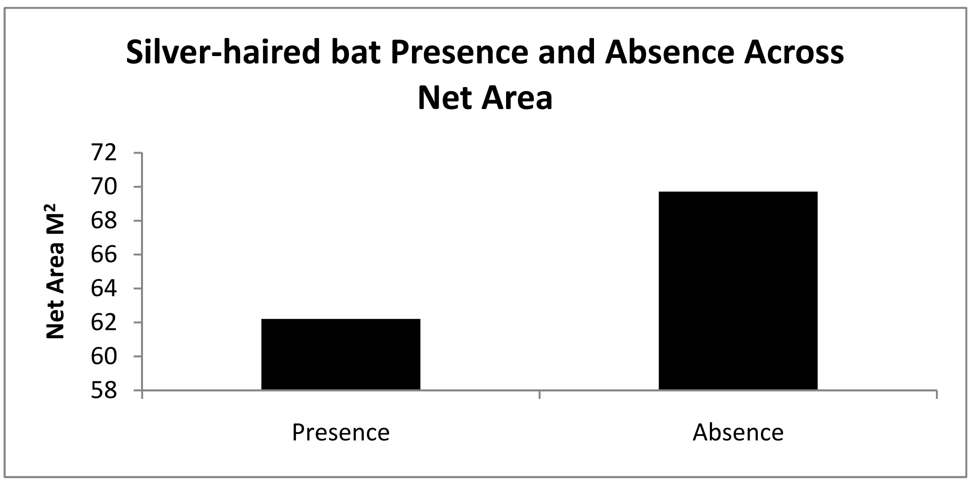


Figure 11. Mean net area for silver-haired bat presence and absence events.

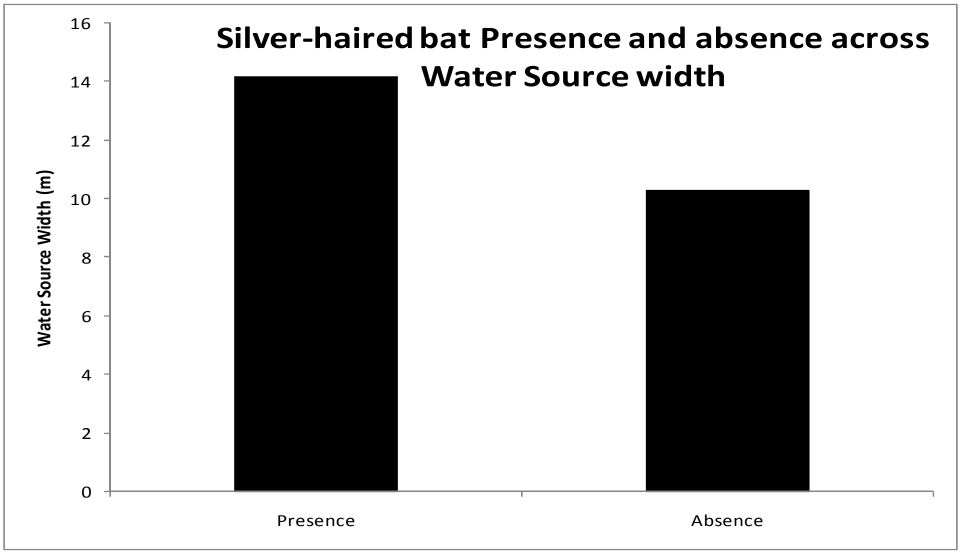


Figure 12. Mean water source width for silver-haired bat presence and absence events.

The best fit model for the California myotis, *Myotis californicus*, was a four variable set (Table 10). The presence of this species was associated with Colorado plateau shrublands and Mojave Desert ecoregions (Figure 13). California myotis was also correlated with a more southerly (Figure 14). This species was associated with a mean elevation as well; 95% of observations occurred between 1200 and 2000m with a mean of 1600m (Figure 15). Finally, California myotis was associated with a water source perimeter between 21 and 107m with a mean water source perimeter of 65m (Figure 16).

Table 10. AIC model fit for California Myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model for this species consisted of Ecoregion, UTM N, elevation and water source perimeter (WSPerimeter).

California Myotis			
Model	K	AIC	ΔAIC
Ecoregion UTMN Elevation WSPerimeter	4	160.779	0.000
UTMN Elevation WSPerimeter	3	161.572	0.793
Ecoregion UTMN Elevation	3	162.134	1.355
UTMN	1	163.167	2.388

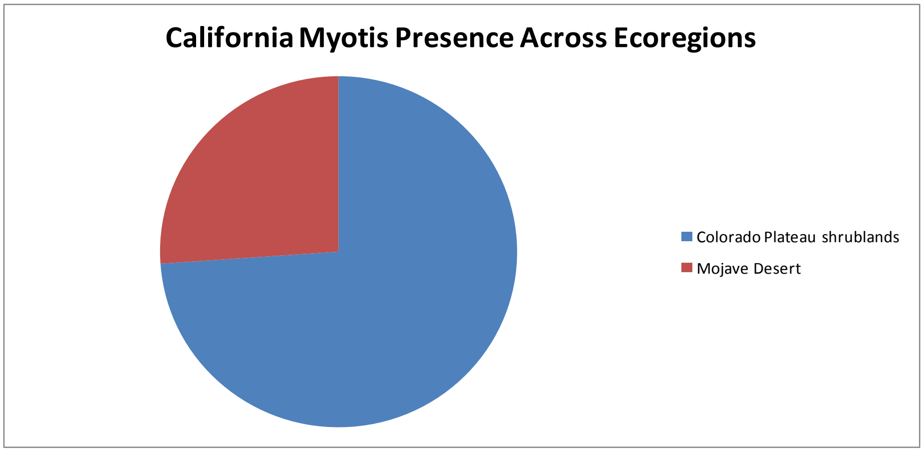


Figure 13. California myotis presence across ecoregions.

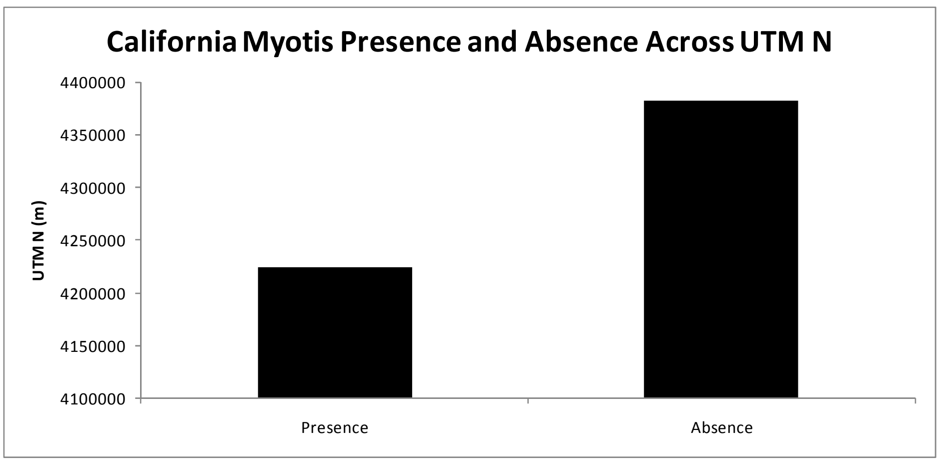


Figure 14. California myotis presence and absence across UTM N.

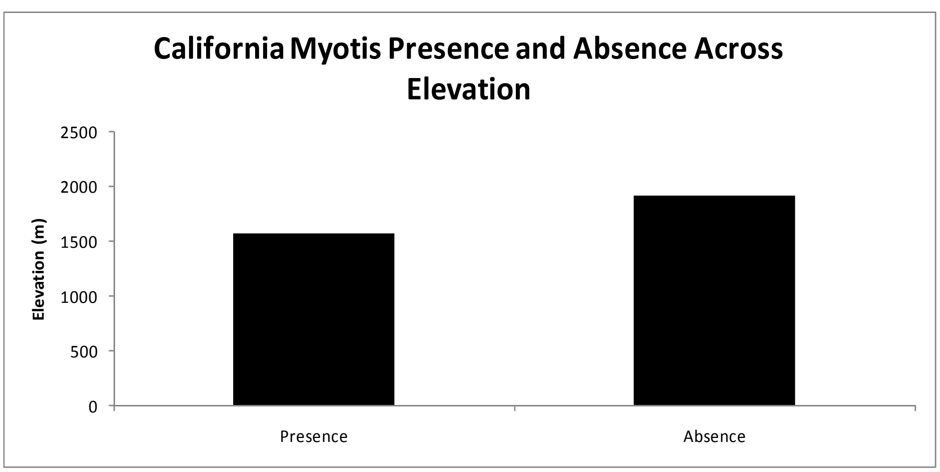


Figure 15. California myotis presence and absence across elevation.

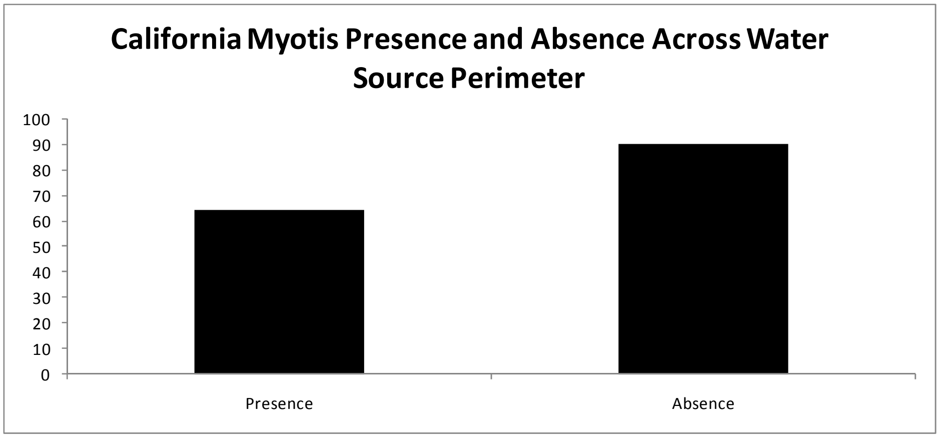


Figure 16. California myotis presence and absence across water source perimeter.

The western small-footed myotis, *Myotis ciliolabrum*, best fit model consisted of a four variable set (Table 11). This species was associated with the Colorado plateau shrublands and the Great Basin shrub steppe (Figure 17). The western small-footed myotis observations were also correlated with water source width; 95% of observations occurred between 4 and 13m with a mean of 9m (Figure 18). Observations of this species were associated with new moon and full moon phases (Figure 19). Finally, western small-footed myotis observations were associated with the earthen tank water source type (Figure 20).

Table 11. AIC model fit for western small-footed Myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model for this species consisted of Ecoregion, water source width, moon phase and water source type (WSType).

Western Small-footed Myotis			
Model	K	AIC	ΔAIC
Ecoregion WSWidth Moonphase WSType	4	167.613	0.000
Ecoregion Elevation WSWidth Moonphase WSType	5	167.892	0.279
Ecoregion Moonphase WSType	3	168.129	0.516
MoonPhase	1	170.933	3.320

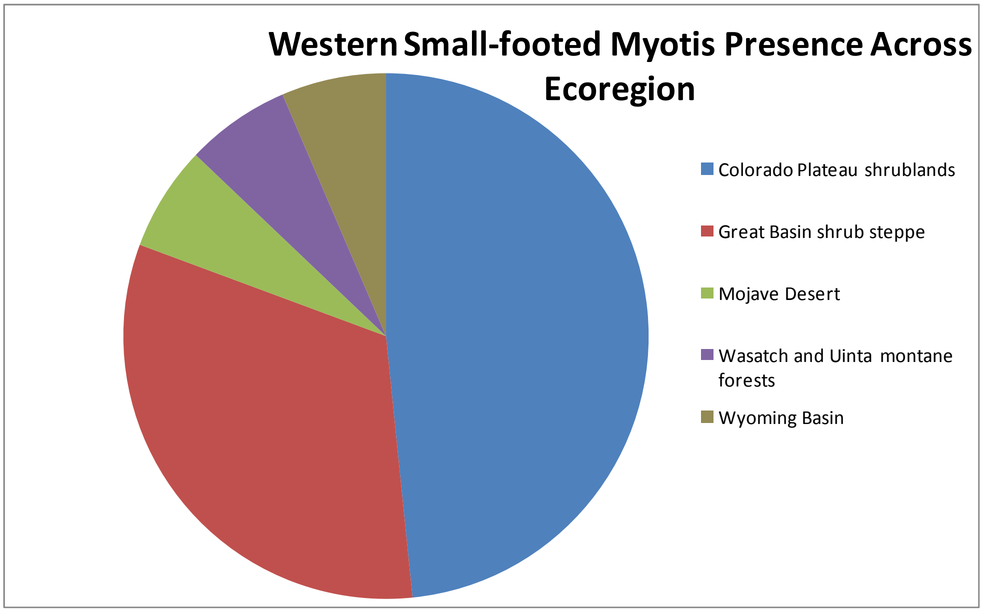


Figure 17. Western small-footed myotis presence across ecoregion.

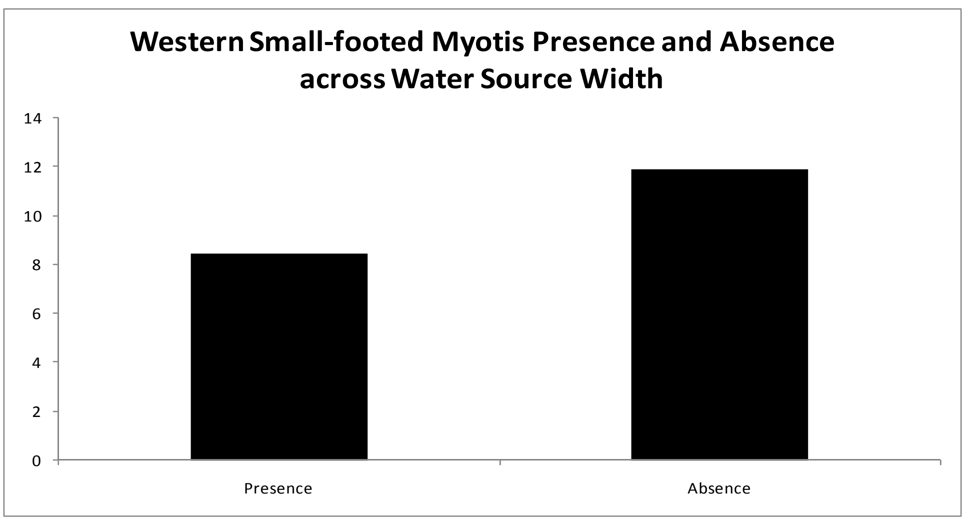


Figure 18. Western small-footed myotis presence and absence across water source width.

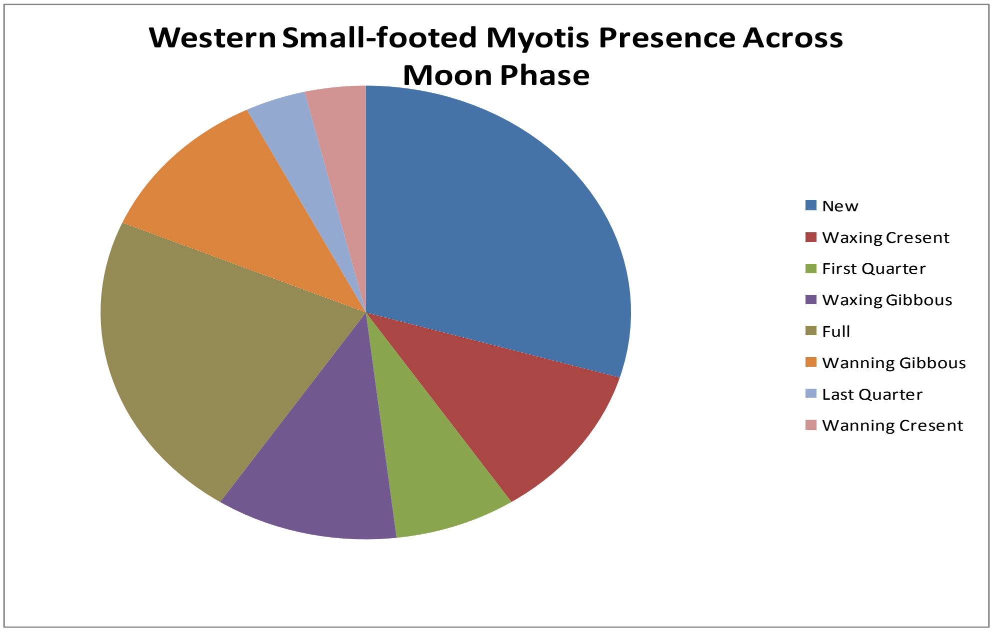


Figure 19. Western small-footed myotis across moon phase.

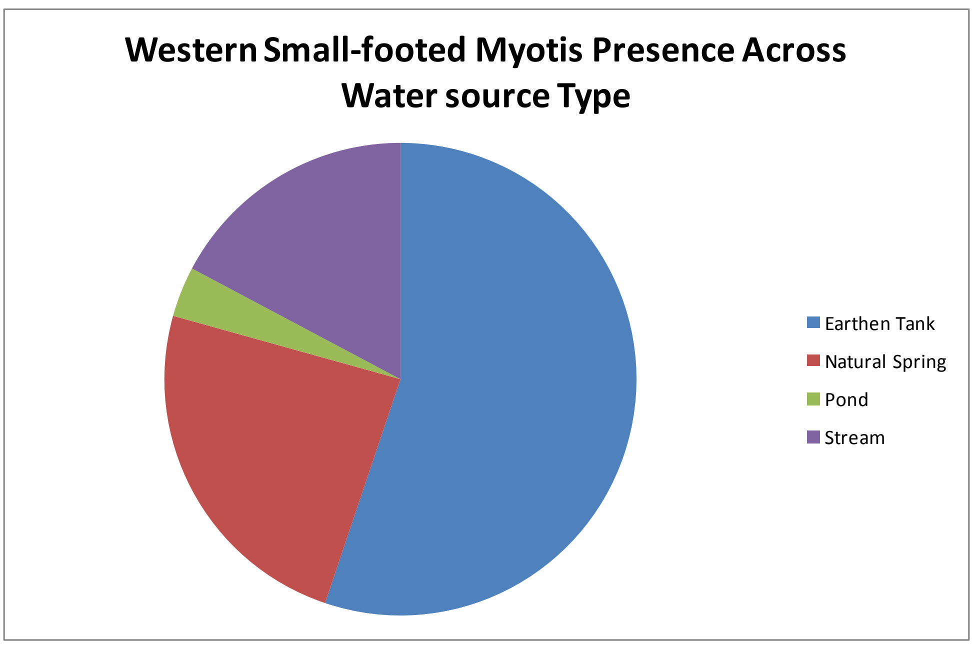


Figure 20. Western small-footed myotis presence across water source type.

The long-eared myotis best fit model consisted of three variables (Table 12). This species was correlated with a generally northern UTM N (i.e northern portion of state) (Figure

21). Long-eared myotis was correlated with elevations between 1700 and 2500m with a mean elevation of 2100m (Figure 22). Finally, observations for this species were correlated with water source perimeter between 20 and 200m and a mean of 115m (Figure 23).

Table 12. AIC model fit for long-eared myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model for this species consisted of northerly distribution, elevation, and water source perimeter.

Long-eared Myotis			
Model	K	AIC	ΔAIC
UTMN Elevation WSPerimeter	3	198.96	0.000
Elevation WSPerimeter	2	198.977	0.017
Ecoregion UTMN Elevation WSPerimeter	4	200.096	1.136
Elevation	1	204.531	5.571

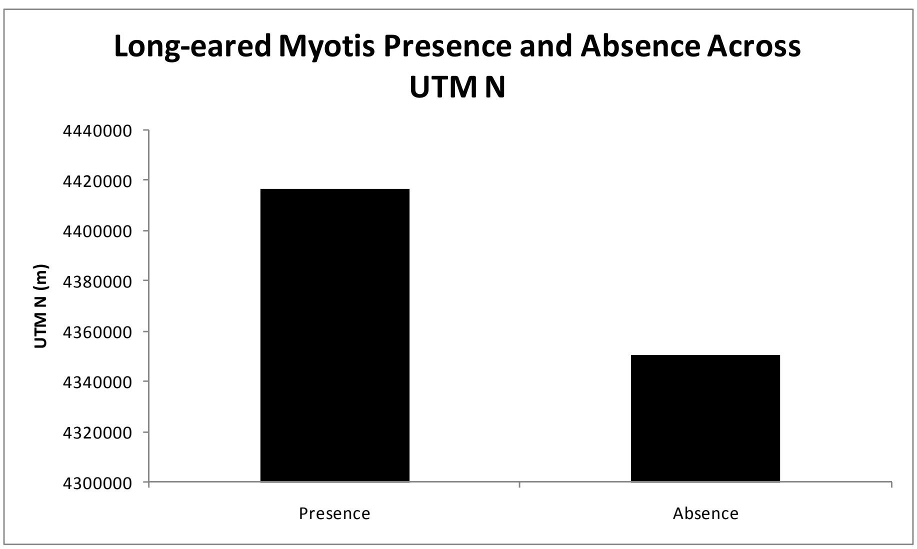


Figure 21. Long-eared myotis presence and absence across UTM N.

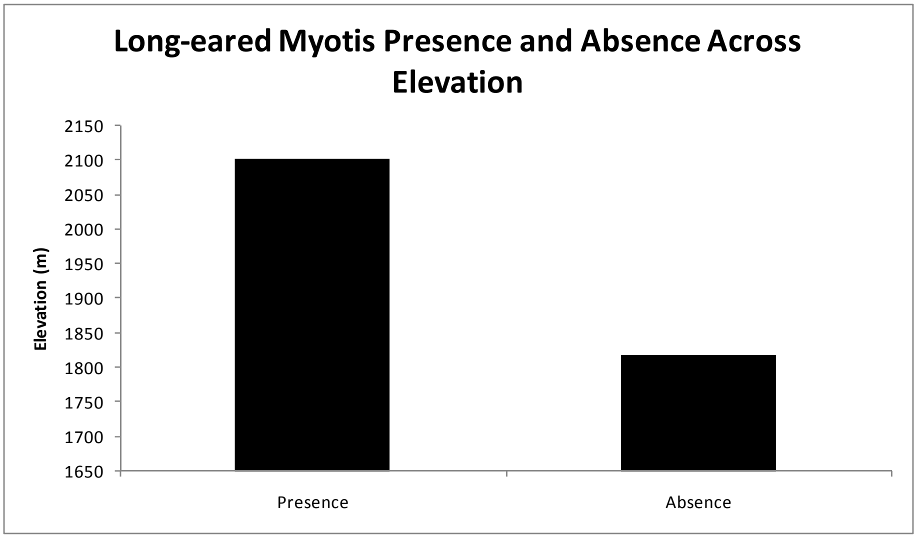


Figure 22. Long-eared myotis presence and absence across elevation.

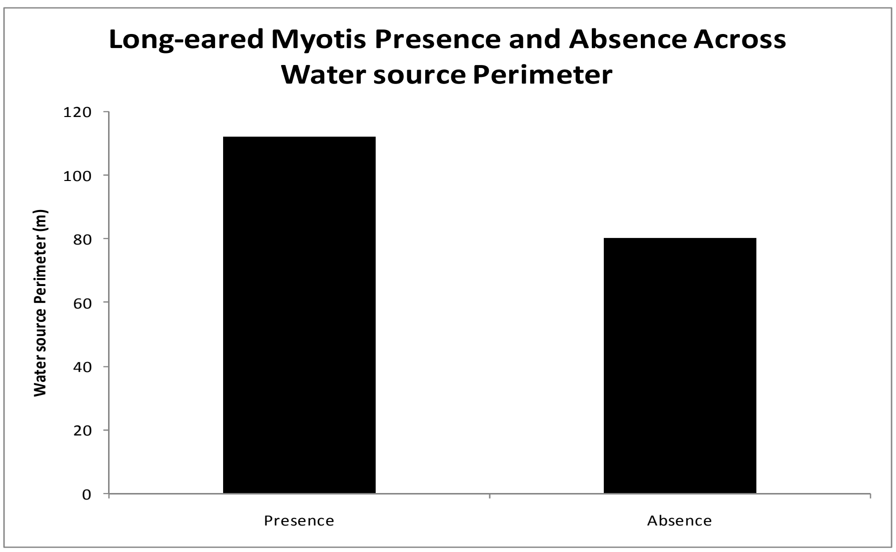


Figure 23. Long-eared myotis presence and absence across water source perimeter.

The best model for the little brown bat consisted of two variables (Table 13). This species was associated with a generally northern UTM N value (Figure 24). The presence of the little brown bat was associated with a water source width between 3 and 30m and a mean width of 17 m (Figure 25).

Table 13. AIC model fit for little brown bat in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model consisted of northerly distribution and water source width.

Little Brown Bat			
Model	K	AIC	ΔAIC
UTMN WSWIDTH	2	162.341	0.000
UTMN	1	163.097	0.756
UTMN NetArea WSWidth	3	163.356	1.015
Ecoregion UTMN NetArea WSWidth	4	165.077	2.736

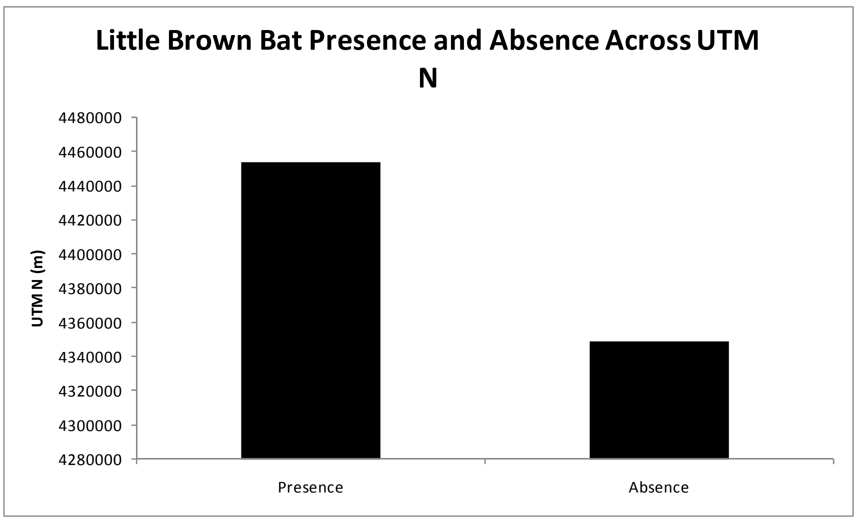


Figure 24. Little brown bat presence and absence across UTM N.

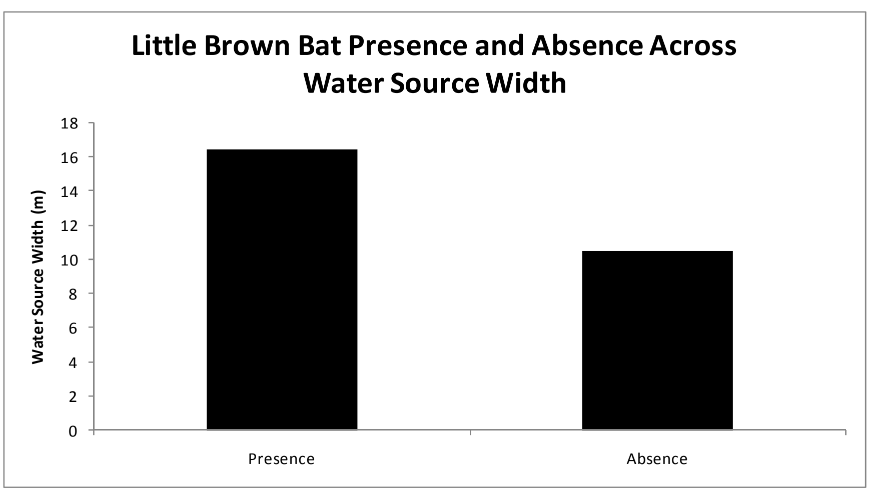


Figure 25. Little brown bat presence and absence across water source width.

The best fit model for the fringed myotis consisted of a two variable set (Table 14). This species was generally associated with a southerly UTM (Figure 26). Observations for the fringed myotis were also correlated with the presence of an earthen tank water source type (Figure 27).

Table 14. AIC model fit for fringed myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model for this species consisted of a southerly distribution and water source type.

Fringed Myotis			
Model	K	AIC	ΔAIC
UTMN WSType	2	113.512	0.000
UTMN Elevation WSType	3	114.269	0.757
Ecoregion UTMN Elevation WSType	4	115.133	1.621
WSType	1	116.033	2.521

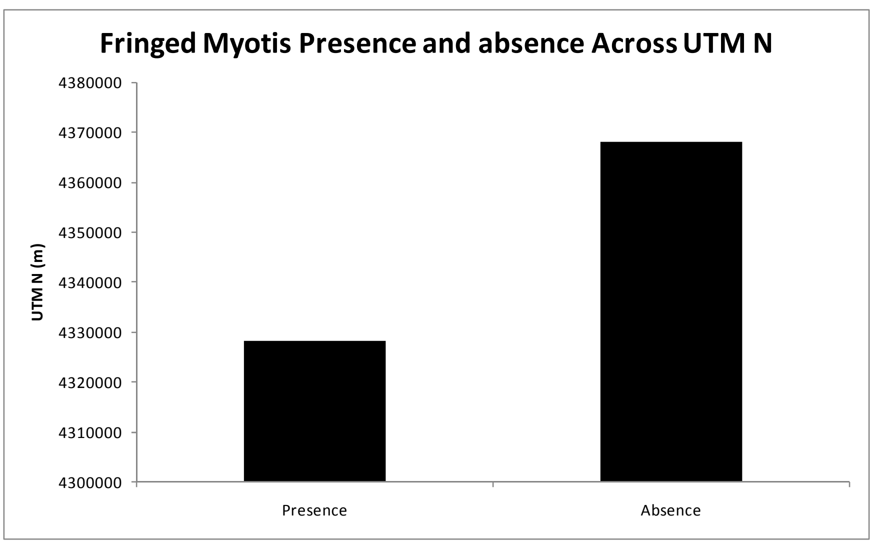


Figure 26. Fringed myotis presence and absence across UTM N.

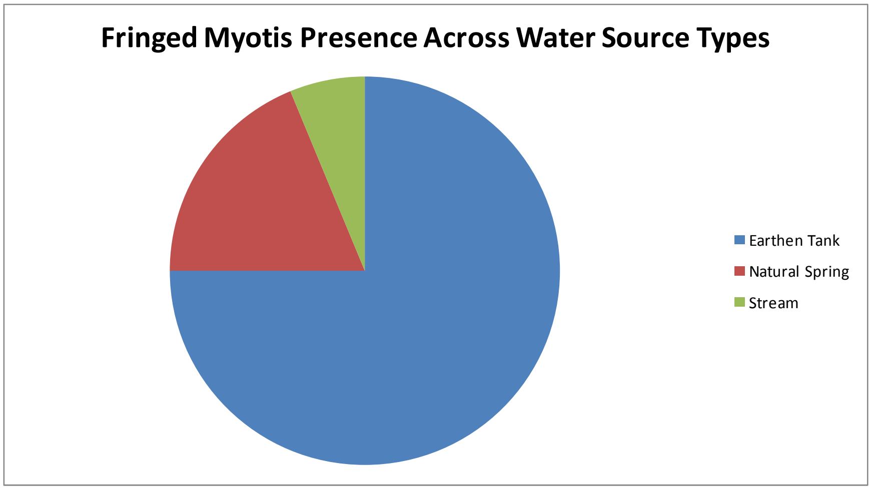


Figure 27. Fringed myotis presence across water source type.

The best fit model for the long-legged myotis consisted of a single variable (Table 15). Observations of this species were associated with elevations between 1700 and 2600m with a mean elevation of 2200m (Figure 28).

Table 15. AIC model fit for long-legged myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model for this species was elevation.

Long-legged Myotis			
Model	K	AIC	ΔAIC
Elevation	1	204.481	0.000
Elevation UTME	2	206.201	1.72
UTME	1	221.765	17.284

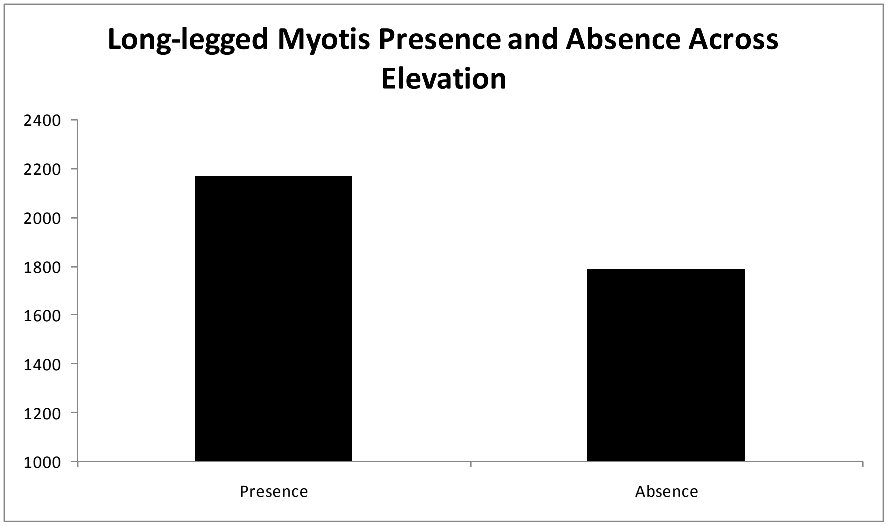


Figure 28. Long-legged myotis presence and absence across elevation.

The best fit model for the Yuma myotis, *Myotis yumanensis*, consisted of three variables (Table 16). This species was associated with the Colorado Plateau shrublands ecoregion (Figure 29), southerly UTM (Figure 30), and understory type (Figure 31).

Table 16. AIC model fit for Yuma myotis in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model. The best fit model consisted of Ecoregion, southerly distribution and understory type.

Yuma Myotis			
Model	K	AIC	ΔAIC
Ecoregion UTMN Understory	3	130.428	0.000
Ecoregion UTMN Elevation Understory	4	131.872	1.444
Ecoregion UTMN	2	132.858	2.43
Ecoregion	1	133.674	3.246

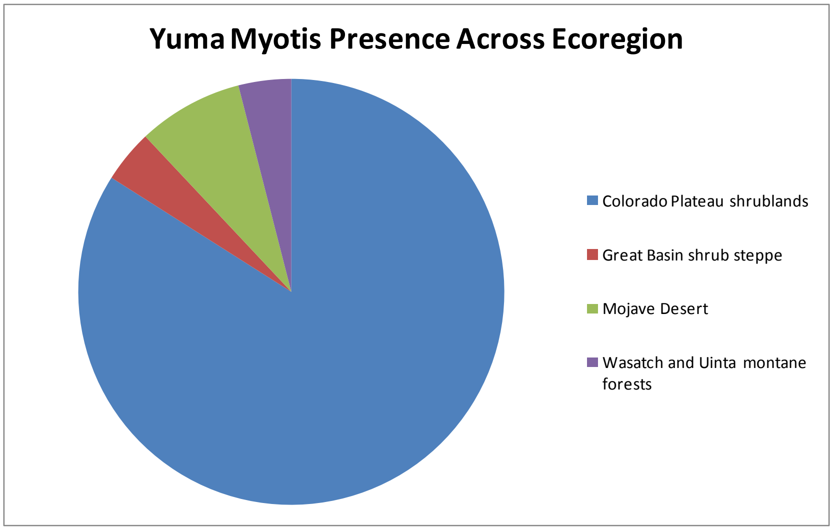


Figure 29. Yuma myotis presence across ecoregion.

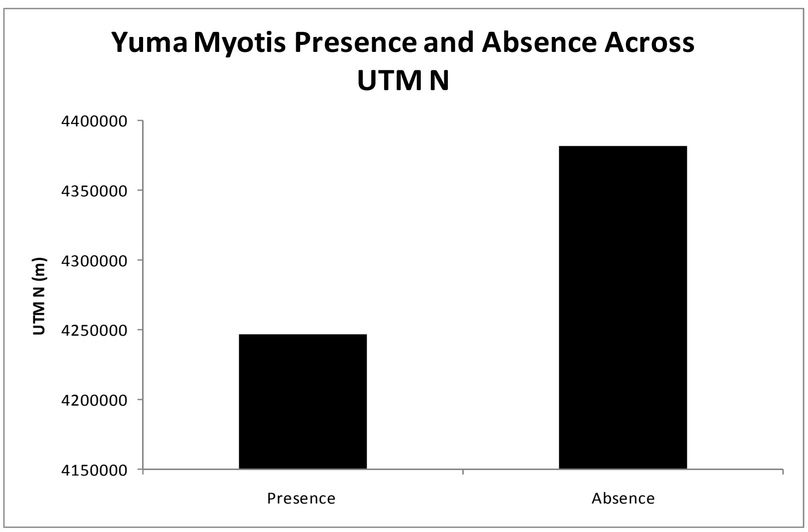


Figure 30. Yuma myotis presence and absence across UTM N.

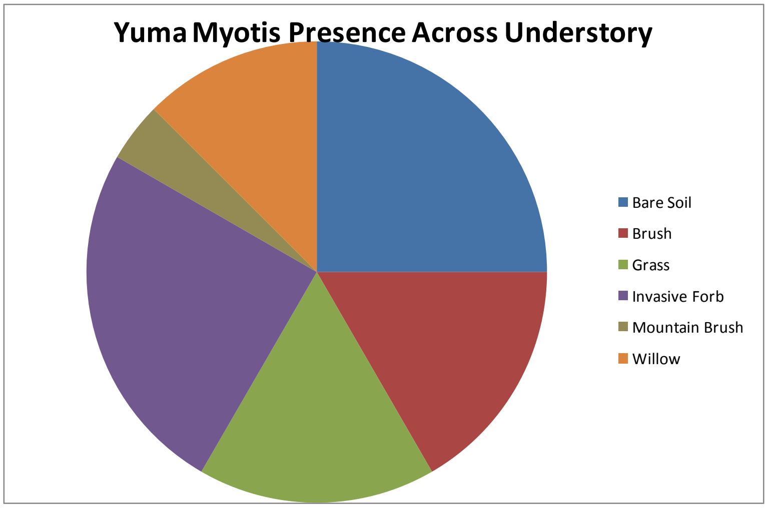


Figure 31. Yuma myotis presence across understory type.

The best fit model for the canyon bat (formally known as the western pipistrelle) consisted of a six variable set (Table 17). This species was correlated with the Colorado plateau shrublands and the Mojave Desert ecoregions (Figure 32). Canyon bats were correlated with more southerly UTM N (Figure 33). Observations of this species were correlated with elevations between 1200 and 1700m with a mean elevation of 1500m (Figure 34). Observations of this species were also correlated with the earthen tank water source type (Figure 35). Finally, observations of the canyon bat were correlated with the brush canopy type and a several understory types (Figures 36 and 37).

Table 17. AIC model fit for the canyon bat in Utah. K is the number of variables in the model, AIC is the Akaike's Information Criterion value for each model and ΔAIC is the difference between each model and the best fit model.

Canyon Bat			
Model	K	AIC	ΔAIC
Ecoregion UTMN Elevation WSType Canopy Understory	6	111.168	0.000
Ecoregion UTMN Elevation WSType Canopy	5	112.899	1.731
UTMN Elevation WSType Canopy	4	112.947	1.779
Elevation	1	159.088	47.920

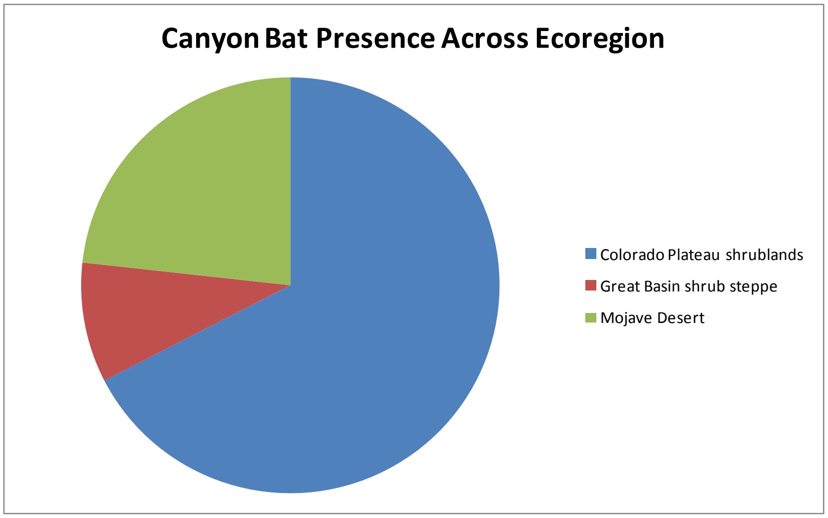


Figure 32. Canyon bat presence across ecoregion.

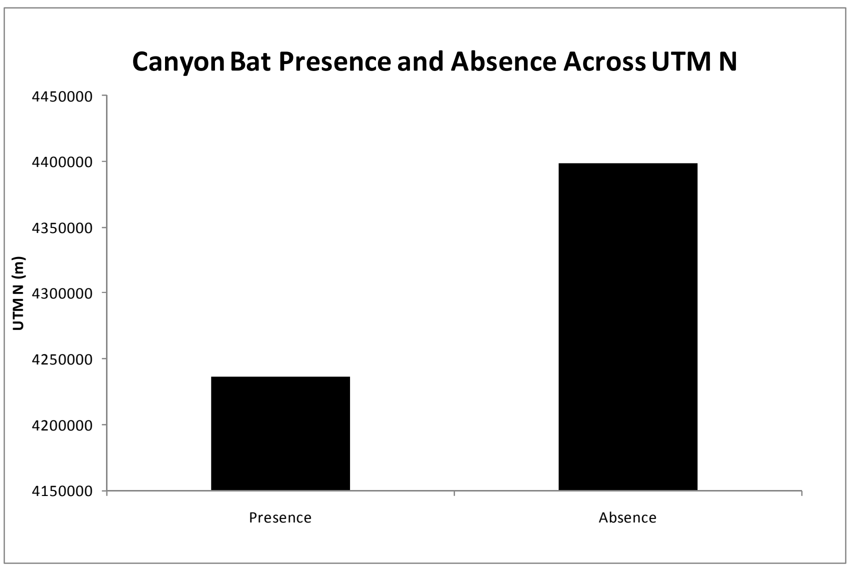


Figure 33. Canyon bat presence and absence across UTM N.

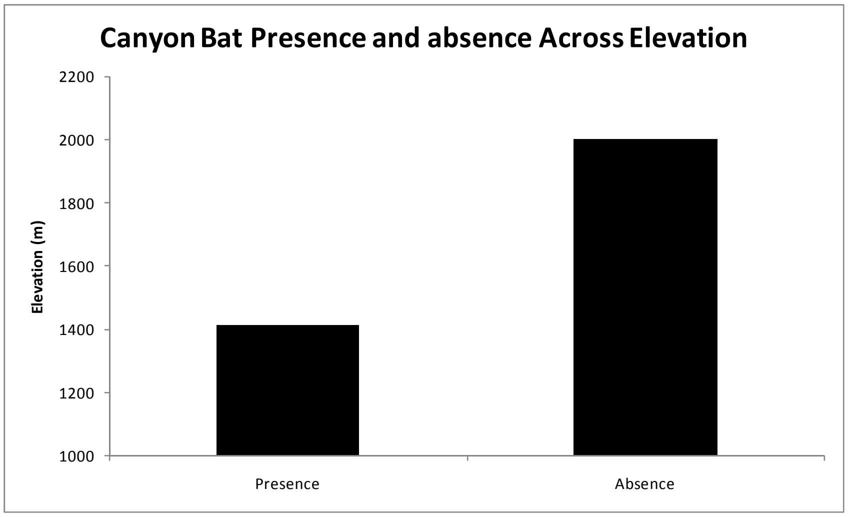


Figure 34. Canyon bat presence and absence across elevation.

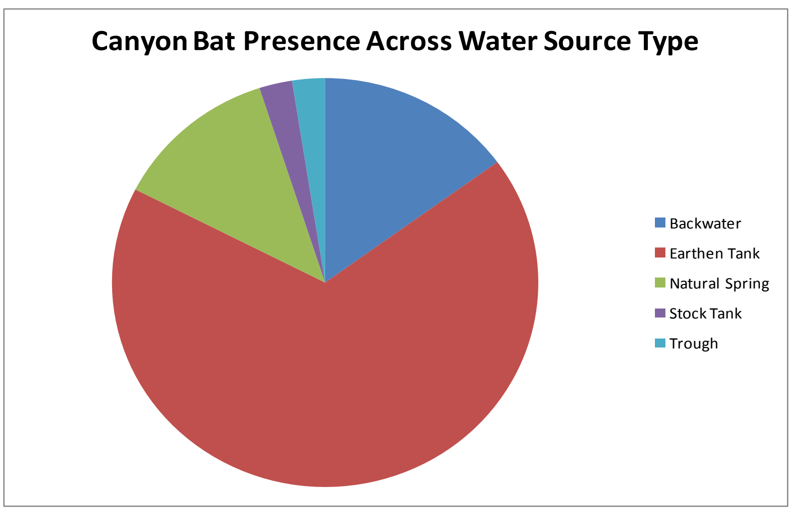


Figure 35. Canyon bat presence across water source types.

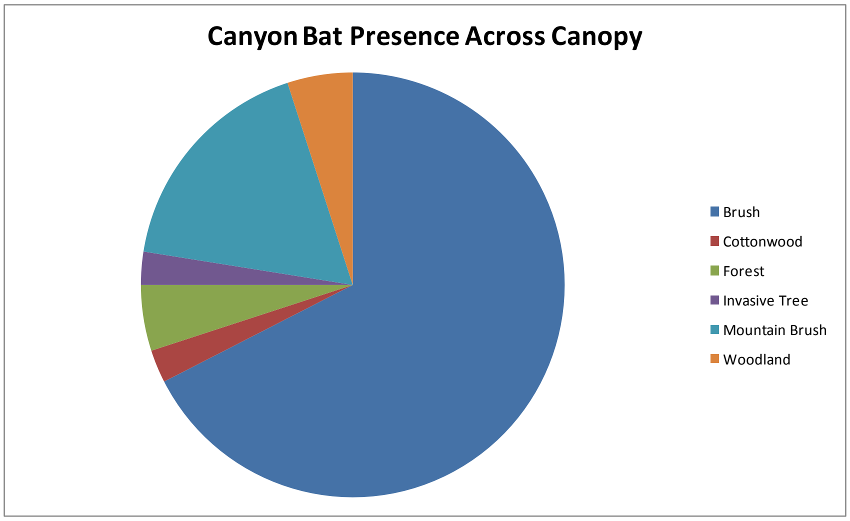


Figure 36. Canyon bat presence across canopy type.

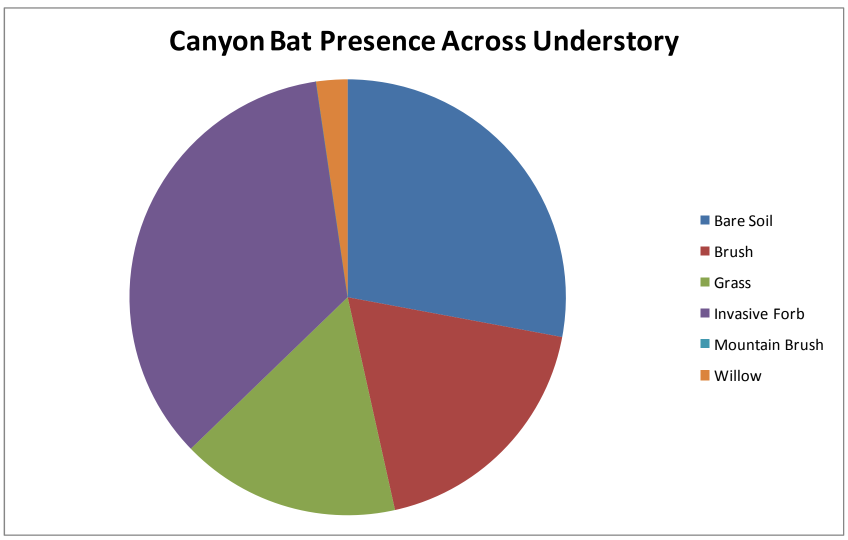


Figure 37. Canyon bat presence across understory type.

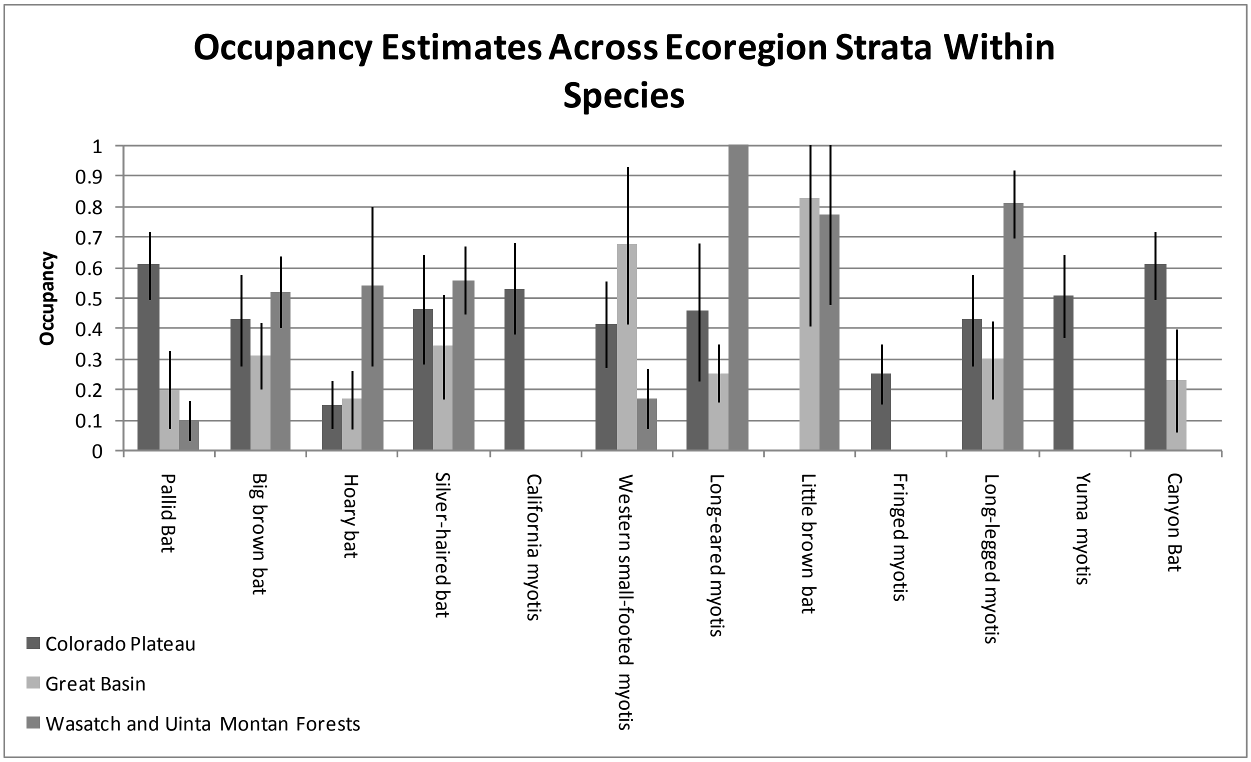


Figure 38. Estimates of occupancy for each species and across three ecoregion strata. California myotis, fringed myotis and Yuma myotis occupancy was only estimated for the Colorado Plateau because < 4 observations occurred in each of the other two ecoregions. The little brown had < 4 observations in the Colorado Plateau and the canyon bat had < 4 observations in the Wasatch and Uinta Montane Forest ecoregion.

Occupancy estimates varied across ecoregion strata within species. Pallid bat occupancy was significantly higher in the Colorado Plateau than all other ecoregions (Figure 38). Occupancy for the hoary bat was significantly greater in the Wasatch and Uinta Montane Forest than other ecoregions. Occupancy estimates for the California myotis consist almost entirely of the Colorado Plateau ecoregion. Western small-footed myotis occupancy was significantly higher in the Colorado Plateau and the Great Basin than in the Wasatch and Uinta Montane Forest ecoregion. Occupancy for the long-eared myotis approached 1 in the Wasatch and Uinta Montane Forest. We were unable to produce occupancy estimates for the little brown bat in the Colorado Plateau. Fringed myotis occupancy was dependent on the Colorado Plateau ecoregion.

Occupancy for the long-legged myotis was significantly greater in the Wasatch and Uinta Montane Forest than all other ecoregions. Yuma myotis occupancy was dependent on the Colorado Plateau. Finally, canyon bat occupancy was significantly greater in the Colorado Plateau than the Great Basin. These ecoregion strata occupancy estimates are the basis for the statewide model estimates (see Species Specific Bat Habitat Models: Random Forest Analysis Report, a Legacy 09-346 deliverable).

DISCUSSION

This study evaluated occupancy and detectability for 12 bat species in Utah. As expected this framework failed to estimate occupancy and detectability of rare and difficult to detect species (Weller 2008). Occupancy estimates varied across species as observed in other taxa (Long et al. 2007b; Tyre et al. 2003). The presence of bat species was correlated with a suite of sample site covariates. Best fit presence models for species varied from single variable models to 6 variable combination models. Variable correlations are based within the bounds of AIC analysis. Model fit is a subjective comparison between competing models. Thus the estimates provide here are dependent on the competing models presented not a percent of variation within models. This is one of few studies to evaluate occupancy and detection for bats at a regional scale (Weller 2008).

While we were able to produce statewide occupancy and detectability estimates for 12 bat species the protocol failed to estimate these values for 6 of Utah's bat species. Three species, Mexican free-tailed bat, Townsend's big-eared bat and the big free-tailed bat were not observed in sufficient numbers due to the ecology of these species. Mexican free-tailed bats roost in large colonies in high temperature caves and building roosts (Adams 2003). This species generally forages at elevations above 2000m and foraging areas may be more than 50km from the roost site (Glass 1982). Mexican free-tailed bats are likely distributed across the state in several large roosts. Therefore if a sample cell does not contain one of these large roosts it is unlikely that Mexican free-tailed bats will be detected. Townsend's big-eared bats are dependent on cavern systems for roosting sites (Adams 2003). This species generally has a small home range which contains both suitable summer and winter roosting sites (Kunz and Martin 1982). If a sampling cell does not contain suitable cavern roosting habitat then the Townsend's big-eared bat is

unlikely to be observed. The big free-tailed bat was not observed in sufficient numbers due to the combination of low sampling in suitable habitats and natural rarity (Durrant 1952; Forester et al. 1997). This species roost high on cliff walls and forages over large bodies of open water adjacent to roosting sites. Therefore if a sampling cell does not contain suitable cliff roosting sites this species is unlikely to be detected. Three species, Allen's big-eared bat, spotted bat and western red bat, were not captured in sufficient numbers simply due to natural rarity (Wilson and Ruff 2000; Adams 2003).

Townsend's big-eared bat and the Mexican free-tailed bat are cavern roosting obligates. These two species are readily detected by conducting mine and cave surveys. Therefore, if we seek to estimate the detectability and occupancy of these two species a cavern/mine survey component should be added to the protocol. One possible option for accomplishing this would be to survey a subset of known cavern habitat within each sample cell. Sample sites could be selected from the existing Utah Division of Oil, Gas and Mining species specific mine data base. A second source of sample sites for these species could be the BATBASE data base which has multiple records for Mexican free-tailed bat roosts. In these ways a cavern survey component could also be derived from the existing mine and cave survey data in the state.

Big free-tailed bats are strongly associated with high cliff walls as roost sites and large bodies of water for watering sites (Adams 2003). This protocol was designed around a $400m^2$ water source sampling site that was high graded within a randomly selected sample cell. If we wish to estimate the occupancy and detectability of big free-tailed bats we could include 10 to 15 additional sampling cells that encompass high cliff walls and bodies of water in excess of $3000m^2$. Given the difficulty of capturing bats at large water sources this methodology by necessity would be acoustically based.

Allen's big-eared bat, spotted bat and western red bat species appear to be naturally rare on the landscape (Wilson and Ruff 2000; Adams 2003). As expected we failed to estimate occupancy and detectability for these species. Only 166 Allen's big-eared bats, 120 spotted bats and 19 western red bats have been captured in Utah over the last 103 years (Legacy II 08-386). Thus, no variation in this protocol is likely to increase the observation of these three species. High intensity species-specific protocols will need to be created and implemented for each of these species if we want to determine occupancy and detectability and interpret population trends. It is important to note that the analysis discussed here is based on capture surveys conducted in 2009. Acoustic surveys were conducted in conjunction with the capture surveys, but data collected during these acoustic surveys has not yet been analyzed. Acoustic data will be analyzed in the same way as capture data once calls have been identified to species using Sonobat 3.0 (soon to be released). Acoustic surveys were designed to detect rare and difficult to capture species such as Allen's big-eared bat, spotted bat and western red bat. The inclusion of the acoustic occupancy model will therefore likely increase the detectability of these three rare species.

Sampling locations are provided for each sample cell and each period for sample cells in Figure 1. Some sample sites were changed between sampling periods due to the scarcity of water resources. The rarity of surface water in Utah and the tendency for those water sources to dry up over time required us to reselect locations for 25 of the sample cells in order to meet the model assumption of water source size. Precipitation in May and June was near average for Utah while precipitation in July and August was far below average, making it the 6th driest summer in Utah history. This near complete lack of mid and late summer rain lead to the drying of many water sites that were assumed perennial. When cell reselection was conducted, we

attempted to move the cell to habitat similar to the original location. We also attempted to move the cells the shortest distance possible in order to meet the water site size restriction. Sampling sites during the third period are more likely to contain water through the entire sampling season and therefore we recommend that the period three sampling location be used for the next iteration of this protocol.

MANAGEMENT IMPLICATIONS

The findings of this study can be used to better allocate resources for monitoring bat taxa on a landscape scale. By calculating the detectability of the 12 bat species discussed here we are able to estimate the sampling intensity required to create a complete picture of biodiversity at a site. By estimating occupancy we can better understand the distribution of bat species in Utah. While the study detailed here focuses on the simple presence and absence of species, we also collected demographic age and sex class data for each species. If the protocol is carried out for a second iteration, we can estimate the change in cell occupancy across age and sex classes and thus provide a measure of population trend. A second iteration of the model (sampling in year four, or 2012) will allow for not only a covariate analysis but also a stage (age and sex ratio change) analysis. We can compare survey periods across years to evaluate the age and sex structure of bat populations, thereby creating a multiple stage robust occupancy model. Further iterations of the protocol will allow for population level evaluation of bat species in Utah and even estimations of population status. If this is to be the terminal stage for this protocol, the findings here can be used to further standardize collection techniques in order to better monitor bat distributions and covariate relationships. In summary, this study provided the basis for a long term landscape level monitoring project. A commitment has been made throughout the state to repeat this monitoring protocol at three year intervals. Support from various agency land managers, the UDWR, and the UBCC will ensure that the additional data discussed here will be collected and analyzed after 2012 and 2015 iterations and beyond.

REPEATABILITY NOTE

All sampling site information and data input formats used in the estimate of occupancy and detectability are within Appendix V. This appendix includes: data input format for program MARK, data input format for SAS statewide presence analysis, and SAS code example for presence analysis. This appendix will allow for broad scale analysis to be repeated in the same fashion described within this document.

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APPENDIX

Appendix I. UBCC Capture Data Sheet (front)

Bat Survey Data Form 1. Page ____ of ____

2. Date: ____________ 3. Capture Location: ____________ 4. County/State: ____________

5. Habitat/Site Description: ____________ 6. Photographs: N ____ S____ E ____ W ______

7. UTM Coordinates (NAD83): ☐☐☐☐☐☐ E ☐☐☐☐☐☐☐ N 8. Zone: ☐☐☐ 9. Elevation (m): ____________

10. Accuracy (circle): ≤30m ≤300m ≤3km 11. Team Lead: ____________ 12. Other Team Members: ____________

13. Methods Used: a) Mist Nets (# nets)________ b) Harp Net (# nets) ________ a/b) Sum All Net Lengths (m) ________ Total Net Area (m^2) ________

c) Acoustic Detector Method (circle): No Acoustic Remote/Stationary Hand Release Transect Other____ Detector Type (Brand, Model): ____________

d) Data logger (data type/N) ____________ (interval in minutes) ________ Notes: ____________

15.	START	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	END	Total
16. Time (24 hr):												
17. Net/Trap Status:	/	/	/	/	/	/	/	/	/	/	/	/
18. Detector Status:												
19. Logger Status:												
20. Temp (°C):												
21. Wind:												
22. Weather:												
23. Moon:												

24. Bat No.	25. Time (24 hr)	26. Temp (°C)	27. Species	28. FA (mm)	29. Ear (mm)	30. Tragus Shape	31. Keel (Y/N)	32. Gender (M/F)	33. Reproductive Status	34. Age (Juv/ Sub/Ad)	35. Wing Score (0, 1, 2, 3/P)	36. Photo? (Y/N/#)	37. Mark? (Y/N)	38. Weight (g) "Tared"	39. Notes

ARE ALL THE FIELDS FILLED OUT COMPLETELY? PLEASE INITIAL:_____

Appendix II. UBCC Capture Data Sheet Data Dictionary (back). *Should be used to augment the data sheet in Table 2 and 3.*

<u>Field Descriptions for Bat Survey Data Form</u>

1. **Page__ of __:** Fill in the first blank with the current page number and the second blank with the total number of pages used during the survey period (ex. Page 2 of 3).
2. **Date:** The Day, Month, and 4 digit Year the survey was conducted (23 June 2005).
3. **Capture Location:** The ‘common’ name of the site being surveyed (ex. Nirvana Pond or Selman’s Ranch House).
4. **County/State:** The County and State in which the survey is being conducted (ex. Box Elder County, UT).
5. **Habitat/Site Description:** Short, simple description of surroundings and dominant vegetation within one mile of survey site. Description should also include the characteristics that caused the site to be selected (ex. presence of a stock pond, mine shaft, roost, etc.) and ownership of the land if known (USFS, state, private, etc.)
6. **Photographs:** Take one photograph in each cardinal direction (N,S,E,W) from the location the Coordinates were recorded (see #7). Note number of photograph if digital and applicable. Future photographs should always be taken from the same location to simplify historical comparisons.
7. **UTM Coordinates:** Record easterly (6 digit) and northerly (7 digit) UTM coordinates of the survey site using a GPS unit.
8. **Zone:** Record the UTM zone as 11, 12, or Unknown
9. **Datum:** Original site location datum is defined by user's GPS or map datum; e.g. NAD27 Conus or NAD83.
9. **Elevation (m):** Use a GPS unit to record the Elevation at the same location the site’s Coordinates were taken (see #7). Record elevation in meters.
11. **Accuracy:** Record accuracy of coordinates as <30 m (determined from GPS), <300 m (determined from USGS topomap), <3 km (determined from vague description, historical data, or TRS), or Unknown.
12. **Team Members:** Record the first and last names of the individuals conducting the survey. Record professional affiliations if applicable (ex. USFWS, USFS, TNC, etc.)
13. **Team Lead:** Record the full name and affiliation of the individual responsible for the data on the field form (completeness and accuracy); insuring questions regarding this survey can be directed to that person.
14. **Methods Used:** Indicate the number of methods (nets/traps/detectors) used during the current survey with a ‘Y’, and an ‘N’ for those not used. If mist nets are being used, record their overall length and calculate their surface area in square meters [surface area = height (m) x sum length of all nets open (m)]. If a data logger is being used, note the type of data it is collecting (ex. temperature, humidity, barometric pressure) and the intervals to which it is set to collect data (ex. 5 min.). Use the Other category to record other methods employed during the survey period.
15. **Start; Hour 1…:** The status of Fields 13-20 should be recorded at the Start of the survey period and each consecutive 60 minutes after until the end of the survey. Uneven starting or ending times of either the nets, data loggers, or ultrasonic detectors should be recorded in the Hour column closest to the event. The actual time for each event will be recorded in Field 13.

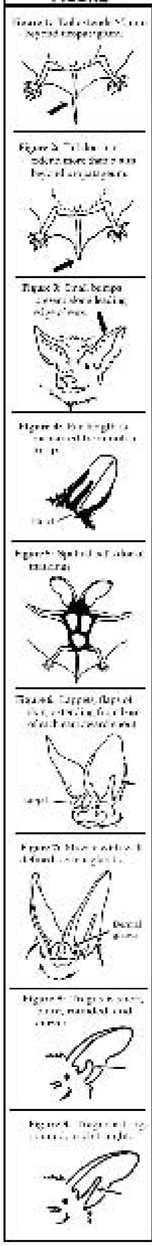
16. **Time:** Actual time that the status of Fields 14 thru 20 are recorded.
17. **Net/Trap Status:** Record whether nets or harp traps are 'O'pen or 'C'losed at time in Field 13. (ex. 'O / C' = open trap & closed trap; 'NA / O' = not using nets / open harp trap)
18. **Detector Status:** Recorded whether an ultrasonic detector is 'Active' or 'Not Active' at time in Field 13.
19. **Logger Status:** Recorded whether a data logger is 'Active' or 'Not Active' at time in Field 13.
20. **Temp (°C):** Record the temperature in degrees Celsius at time in Field 13.
21. **Wind:** Use MPH categories as determined from the Beaufort Wind Scale. 1) *0-1 MPH*: Calm; smoke rises vertically. 2) *1-3* MPH: Direction of wind shown by smoke drift, but not by wind vanes. 3) *4-7* MPH: Wind felt on face, leaves rustle, ordinary vane moved by wind. 4) *8-12* MPH: Leaves and small twigs in constant, gentle motion; wind extends light flag. 5) *13-18* MPH: Raises dust and loose paper; small branches are moved. In most situations winds in categories 3, 4,and 5 will not be conducive to operating mist nets.
22. **Weather:** Record the dominant weather over the last hour: 1*) Clear*: 0-10% cloud cover. 2) *Partly*: 10%-50% cloud cover. 3) Cloudy: 50%-100% cloud cover. 4) *Precip:* some amount of precipitation fell.
23. **Moon:** Record phase of moon as: 1) *None*: Either a new moon, or it hasn't risen yet. 2) *Crescent*: 0-25% lit. 3) *Half:* 25-75% lit. 4) *Full*: 75-100% lit. 5) *Obscured*: Obscured by cloud cover.
24. **Bat No.:** Number the bats as they are caught (ex. 1, 2,3 …).
25. **Time (24 hr):** The time the bat *was caught*, not the time it was processed (ex. 2234).
26. **Temp (°C):** The temperature in degrees Celsius when the bat *was caught*, not when it was being processed.
27. **Species:** Use a dichotomous bat key for the area the survey is being conducted to help identify bats to species. It is likely that characters in addition to the Fields below will be needed for proper identification.
28. **FA (mm):** The length of the forearm in millimeters. The forearm is defined as the length between the elbow and the distal side of the wrist (Figure 1).
29. **Ear (mm):** The length of the ear in millimeters. The ear length is measured from the notch on the base of the ear to the ear's tip (Figure 2).
30. **Tragus Shape:** Note the shape of the tragus as either 1) Long and Pointed (Figure 3a) or 2) Short and Rounded (Figure 3b). Especially useful to determine identification of Pipestrelles (canyon bat).
31. **Keel:** Note the 1) Presence or 2) Absence of a flap of skin hanging loose off the posterior edge of the calcar (Figure 4a & b).
32. **Gender:** Record the sex of the bat as 1) Male or 2) Female. Evidence of sex is best obtained from the genitalia, with the males possessing a well developed penis.
33. **Reproductive Status:** Record the reproductive status of the Males as either 1) Reproductive – one or both testes have descended or 2) Non-reproductive – neither testes are descended. For the Female note evidence of 1) Lactating – nipples are pink and enlarged, hair surrounding the nipple is worn. 2) Post-lactating – nipples wrinkly and dark hair has often grown back. 3) Pregnant – presence of unborn fetus evident. 4) Non-reproductive – nipples very small and well haired.

34. **Age:** Record as either 1) Juvenile [non-volant + A in Fig. 5], 2) Sub-adult [volant + A in Fig. 5], or 3) Adult [B in Fig. 5]. Phalangeal joints are best observed by shining the joints from behind with a head lamp.
35. **Wing Score:** Record the wing damage. Score damage as 0) no damage, 1) light damage, 2) moderate damage, 3) heavy damage, then add a P for any physical damage with description in notes. (Example: 1/P light splotching and a physical tear in membrane. Refer to Reichard 2008 for further explanation of scoring.
36. **Photo?:** Record whether a photograph was taken of the bat with a Yes (Y) or (N). Note number of photograph if digital and applicable.
37. **Mark?:** Record whether the animal was marked before release with a Yes (Y) or No (N). Note method of marking in the Notes (ex. Marker, band, tattoo, freeze brand, etc.)
38. **Weight:** The total weight of the bat minus the weight of the bag in grams.
39. **Notes:** To be used to record observations or actions of this particular bat not accounted for by the data sheet (ex. parasite load, marking method, previously marked, injuries, capture method, etc.)

Appendix III. Dichotomous Key for the Bats of Utah.

DICHOTOMOUS KEY FOR THE BATS OF UTAH

Authored by: Chris Witt, Adam Kozlowski, and George Oliver
Figures by: Adam Kozlowski
Last edited: 25 July 2007



STEP		DIAGNOSTIC
1	a.	Tail extends beyond rear edge of uropatagium (interfemoral membrane) by more than 5 mm [Figure 1]. GO TO: 2 FAMILY: Molossidae
	b.	Tail does not extend beyond rear edge of uropatagium or only slightly (≤5 mm) [Figure 2]. GO TO: 3 FAMILY: Vespertilionidae
2	a.	Ears do not join at the base, small bumps are present along the ear's front edge. Ears barely extend past the shout when laid forward. Tail generally does not extend >25 mm past interfemoral membrane; usually extends ~19 mm. Fur is generally uni-colored, darkish gray/brown, species often exudes strong, musty odor. **BRAZILIAN FREE-TAILED BAT** *(Tadarida brasiliensis)*
	b.	Ears join at the base, small bumps along the front edges of the ear are not present [Figure 3]. Ears extend well beyond the snout when laid forward. Tail generally extends at least 25 mm past interfemoral membrane. Fur is bi-colored, almost white at its base, distal color ranges from reddish-brown to black. **BIG FREE-TAILED BAT** *(Nyctinomops macrotis)*
3	a.	Ears longer than 25 mm [Figure 4]. GO TO: 4
	b.	Ears shorter than 25 mm. GO TO: 7
4	a.	Three conspicuous white spots present on back, one on each shoulder and one on lower back; [Figure 5]. Ears are pink. **SPOTTED BAT** *(Euderma maculatum)*
	b.	Three dorsal spots not present. GO TO: 5
5	a.	Ears clearly separated at base; dorsal pelage is light brown to yellow, hairs lighter at base. **PALLID BAT** *(Antrozous pallidus)*
	b.	Ears joined at base. GO TO: 6
6	a.	Each ear has lappet (flap of skin) near its base anteriorly, which extends forward toward snout [Figure 6]. Muzzle does not have well-defined dermal glands [Figure 7]. **ALLEN'S BIG-EARED BAT** *(Idionycteris phyllotis)*
	b.	Ears do not have basal lappets (flaps of skin) extending anteriorly. Muzzle does have a well-defined pair dermal glands. **TOWNSEND'S BIG-EARED BAT** *(Corynorhinus townsendii)*
7	a.	Uropatagium (interfemoral membrane) heavily furred dorsally. GO TO: 8
	b.	Uropatagium (interfemoral membrane) not heavily furred dorsally. GO TO: 10
8	a.	Weight is generally greater than 20 g; Light colored ears distinctly edged in black. Dorsal pelage pale yellow/brown at base, black/dark brown in middle and white/cream at tip. **HOARY BAT** *(Lasiurus cinereus)*
	b.	Weight is generally less than 20 g. Dorsal pelage is not pale yellow/brown at base, black/dark brown in middle and white/cream at tip. GO TO: 9
9	a.	Fur color is dark brown to black with silver/white tips, giving a frosted appearance. **SILVERED-HAIRED BAT** *(Lasionyceris noctivagans)*
	b.	Fur color is not dark brown to black with silver/white tips, rather it is brick red to rust on upperparts with pale undersides. **WESTERN RED BAT** *(Lasiurus blossevillii)*
10	a.	Tragus short (<6 mm), blunt, rounded, and curved [Figure 8]. GO TO: 11
	b.	Tragus long (>6 mm), pointed, and straight [Figure 9]. GO TO: 12

11 a. Forearm >40 mm (42 – 52); ears extend outward; mass greater than 11 g.
BIG BROWN BAT *(Eptesicus fuscus)*

b. Forearm <40 mm (28 – 33); mass less than 11 g.
WESTERN PIPISTRELLE *(Pipistrellus hesperus)*

12 a. Ears blackish and extend 4mm or more past end of snout when pressed forward.
LONG-EARED MYOTIS *(Myotis evotis)*

b. Ears extend less than 4 mm past end of snout when pressed forward.
GO TO: 13

13 a. Uropatagium (interfemoral membrane) has conspicuous fringe of hairs on its posterior edge; [Figure 10]. Fringe often accompanied by lighter skin pigmentation on uropatagium's trailing edge.
FRINGED MYOTIS *(Myotis thysanodes)*

b. Uropatagium (interfemoral membrane) does not have conspicuous fringe of hairs (but may be very sparsely haired).
GO TO: 14

14 a. Underside of wing has long, dense fur extending outward from body to a line between elbow and knee [Figure 11]. Tibia is ≥ 2.5X the length of the hind foot.
LONG-LEGGED MYOTIS *(Myotis volans)*

b. Underside of wing does not have long, dense fur between elbow and knee.
GO TO: 15

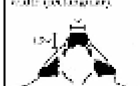
15 a. Calcar keel is not well developed or is absent [Figure 12].
GO TO: 16

b. Calcar keel is present and well developed [Figure 13].
GO TO: 17

16 a. Fur of dorsal region is dull.
Forearm is generally less than 36 mm.
No keel on calcar.
Skull rises more abruptly from snout.
Ventral hairs black at base, light cream at tips.
YUMA MYOTIS *(Myotis yumanensis)*

b. Fur of dorsal region is glossy and long, longest dorsal hairs ~10 mm.
Forearm length 34 – 41mm.
May have poorly developed keel on calcar.
Snout to skull transition gradual.
Hairs on toes project beyond claws.
LITTLE BROWN MYOTIS *(Myotis lucifugus)*

17 a. Naked part of snout top is as wide as it is long (square) [Figure 14].
Tail does not extend beyond uropatagium.
Forehead rises steeply and abrubtly from rostrum.
Face, ears, and wings are not black and do not contrast sharply with pelage color.
CALIFORNIA MYOTIS *(Myotis californicus)*



b. Naked part of snout top is 1.5X the nostril width (rectangular) [Figure 15].
Tail often extends 1.5-2.5 mm beyond uropatagium.
Forehead rises gradually from rostrum.
Face, ears, and wings are black, often contrastingsharply with pale pelage.
WESTERN SMALL-FOOTED MYOTIS *(Myotis ciliolabrum)*

CHARACTERS USEFUL IN DISTINGUISHING UTAH'S SPECIES OF *MYOTIS*

Species	Body Mass (g)	Forearm (mm)	Ear (mm)	Keel on Calcar	Special Characteristics
californicus	3 – 6	29 – 36	9 – 15	Well developed	See step 17 to differentiate.
ciliolabrum	4 – 6	30 – 36	13 – 21	Well developed	See step 17 to differentiate.
yumanensis	4 – 7	32 – 36	12 –15	None	See step 16 to differentiate.
lucifugus	5 – 7	34 – 41	11 – 15	None	See step 16 to differentiate.
evotis	5 – 8	37 – 40	20 – 24	Poor	Ear length is distinctive among *Myotis*.
thysanodes	5 – 7	39 – 46	16 – 20	Poor to None	Short, dense hairs on trailing edge of tail.
volans	6 – 10	37 – 42	10 – 15	Well developed	Fur on wing between elbow and knee. Tibia is ≥2.5X the length of the hind foot.

Appendix IV. Recommend equipment list for conducting bat surveys within the Utah Bat Monitoring Protocol framework.

List of Materials for Bat Surveys

Mist nets (4)	2.6m x 2.6m, 2.6m x 9m, 2.6m x 12m, and 2.6m x 18m; 38mm mesh, 50 denier/2 ply nylon. http://www.avinet.com/avi6_page.taf?fs=1&view=home
Poles (8)	Two 1.5-m (5-ft) segments joined by a sleeve for each end of the net (total of 4 segments). These can be built easily enough from two different diameters of electrical conduit so that they fit together. A small bolt through the smaller diameter pole near its end keeps it from sliding all the way through (sword and scabbard design).
Anchor cord for poles	Strong string or cord (2mm cord works great, usually carried by local outdoor/climbing store) a minimum of 20 feet in length.
Stakes (16 small, 4 large)	Twelve, heavy duty nail like stakes 8 in or longer for rope anchors. Four, 4 foot rebar stakes to support net poles.
Sledge Hammer	4 lb hammer to pound in all stakes.
Millimeter ruler	Flexible plastic, 150 mm (6 in) is sufficient. Cutting the end off so it is even with the “0” mark makes for easier use.
Scales (2-3)	35 g Pesola spring scale. [If your weigh bag is heavy (greater than 10 grams, i.e. cloth) you may want to also carry a 60g scale]. (Purchase online from Ben Meadows).
Zip-lock storage bags	For containing bats while weighing. Do not zip the bag closed while it is occupied. Quart capacity will suffice for most bats.
Small Cloth bags	Small cloth bags with a string closure and paper label to store bats in for short periods of time. Soil sample bags (4 X 6 in) work well (Purchase from Ben Meadows).
Headlamp	This frees both hands for handling bats. We recommend Petzel® DUO 14 because it enables the user to use both an LED and super bright Halogen light.
Handheld flashlight	Small light that can sit in bat kits to assist with aging bats.
Leather gloves	Light-weight for dexterity. Deerskin gloves are very good, with the exception of handling large *Eumops* spp. (Recommend baseball

	batting gloves or golf gloves. Find some that fit relatively tight and have full leather on and between thumb and forefinger).
Watch	To note the time of capture. (Small, Indiglo travel alarm; stands up and is easy to read at night).
Clipboard	For holding data forms. (Enclosed case ones are nice for holding pens, rulers, dichotomous keys, etc.).
Data forms	Both the UBCC and Utah Bat monitoring protocol data forms (Tables 2, 3 and 4, and Appendix I, II).
Pencils	To complete data forms.
Marker: light-colored,	A RED or BLACK Sharpie marker to color the bat between the shoulder blades to detect recaptures.
Camera, film, and flash	For voucher pictures. (Digital point and shoots work great).
Thermohygrometer	Portable. (Kestrel 3000 handheld weather stations online from Ambientweather. The Kestrels measure windspeed, temperature and humidity at the push of a button).
Data Logger	Automatically records ambient temperatures and humidity throughout the night at 5 minute intervals. (Recommend Hobo Pro Data Logger Temp/RH Model H08-032-08 and Boxcar Software; http://www.onsetcomp.com/Products/Product_Pages/HOBO_H08/hobo_pro_family_loggers.html).
Acoustic Equipment	Binary Acoustic equipment; recording equipment, 12 volt car battery, 3 foot rebar stake, waterproof backpack, and four thumb drives.
Bat Key	Dichotomous Utah key (Appendix III).
GPS Unit (1)	For recording the UTM location and elevation of the survey finding your way back to a historical survey site.
Simple, clear	
tackle organizer (1)	Useful to help coordinate batteries, toothpicks, markers, pencils, pencil lead, knife, tweezers, etc. Clear design makes it easy to take inventory after each survey.
Wooden Toothpicks	Useful for the delicate job of getting the bats out of the net; also disposable. Dental picks also work well make certain any net removal tool has been dulled to avoid damaging any bat membranes.

Waders	Hip and/or chest waders to aid in net set up and getting bats out of the net.
Measuring Tape	To measure the size and depth of the water site.
Camp Chairs	To rest between net checks.
Batteries:	Make certain to have back up batteries for ALL field equipment.
Work Table	Collapsible and portable. To aid in bat measuring.
Clorox Wipes	Used to aid in equipment cleaning.
Bleach	Used to aid in equipment cleaning.
Spray Bottle	Used to aid in equipment cleaning.
Paper Towels	Used to aid in equipment cleaning.
Hand Sanitizer	Used to aid in equipment cleaning.
Wash Buckets	Used to aid in equipment cleaning.

Appendix V. Data Input and Code. Data input format for MARK; Data input format for SAS statewide presence analysis; SAS code example for presence analysis. *These are required to repeat this analysis. This appendix will allow for broad scale analysis to be repeated in the same fashion described within this document.*

<u>Example MARK Input File</u>

Note: Must be saved as an inp file. First column in the format 000, 010, 001 etc. refers to the presence (1) or absence (0) of a species during Period 1, Period 2 and Period3. All remaining column refer to the covariates included in the analysis. For this example we include: Second column refers to Ecoregion classs (Colorado Plateau=1, Great Basin=2, Mojave Desert=3, Wasatch and Uinta montane=4, Wyoming Basin=5). Third column refers to UTM N. Fourth Column to Elevation. Fifth column to Water Source type (1=art. Pond, backwater=2, beaver pond=3, earthen tank=4, natural pond=5, natural spring=6, pond=7, stream=8, stock tank=9, trough=10). And Sixth Column refers to Canopy class (brush=1, Cottonwood=2, forest=3, grass=4, invasive tree=5, mountain brush=6, willow=7, woodland=8).

0.0	1	2	4629782	1804	8	8;
000	1	2	4623348	1295	6	1;
000	1	5	4641354	1874	4	8;
000	1	5	4641379	1879	4	8;
0..	1	2	4546832	1340	9	4;
000	1	4	4566637	1266	5	8;
000	1	4	4587596	2188	3	3;
000	1	4	4545243	2108	8	3;
000	1	2	4530351	1363	9	1;
000	1	5	4568442	2131	4	4;
000	1	5	4567957	2131	4	0;
000	1	4	4570998	1921	8	3;
000	1	4	4534152	2744	8	3;
000	1	4	4492907	2522	5	3;

000	1	4	4492882	1791	4	8;
000	1	1	4527263	2354	4	3;
000	1	4	4540499	2575	4	1;
000	1	4	4540499	2575	4	1;
000	1	4	4485595	2910	4	3;
000	1	4	4484337	2824	4	3;
000	1	4	4452748	2376	3	3;
011	1	1	4435033	1572	4	0;
000	1	2	4492269	1432	6	1;
000	1	2	4497788	1298	5	1;
000	1	2	4428918	2004	0	0;
011	1	2	4451854	1459	4	1;
000	1	2	4449906	2196	8	1;
000	1	4	4455101	2169	1	3;
000	1	4	4418625	2482	4	3;
010	1	1	4408139	1965	8	3;
000	1	4	4377913	1692	8	3;
000	1	4	4374448	2689	6	3;
011	1	1	4352171	1763	4	1;
000	1	4	4340801	2652	6	3;
000	1	1	4375320	2206	4	8;
011	1	1	4416768	1589	4	1;
001	1	1	4341816	1416	4	1;
000	1	2	4413578	1340	6	2;
001	1	2	4365259	1471	6	5;

000	1	2	4366527	1395	8	1;
000	1	2	4334555	1389	6	5;
000	1	2	4276579	2027	10	8;
000	1	2	4356509	1898	8	3;
000	1	1	4293717	2586	2	3;
011	1	1	4309403	1231	2	1;
000	1	1	4259408	2687	8	3;
011	1	1	4247611	1283	8	1;
000	1	1	4246564	1888	4	8;
111	1	1	4245933	1639	6	1;
101	1	1	4173789	1439	4	1;
101	1	1	4163347	1639	4	8;
000	1	1	4204282	2046	7	1;
010	1	1	4258669	1897	10	1;
000	1	1	4277476	2881	8	3;
000	1	1	4236744	1863	4	6;
000	1	1	4206900	1902	8	8;
000	1	1	4184666	2848	8	3;
000	1	1	4201843	2096	7	3;
000	1	1	4158270	1758	7	3;
111	1	1	4115877	1257	2	1;
011	1	1	4156987	1724	4	6;
000	1	1	4139656	1935	8	3;
010	1	1	4122124	976	8	3;
000	1	1	4112091	1574	8	6;

111	1	3	4109641	1319	4	1;
111	1	3	4109641	1319	4	1;
010	1	3	4104995	883	4	1;
010	1	3	4104995	883	4	1;
111	1	1	4104394	1672	4	1;

Example SAS input file for the statewide presence analysis.

Note: File must be saved as CSV. Categorical data must be represented in a class based analysis.

periodcor	MYCA	Site	Period	Visit	DWR Regio	Ecoregion (	Datum	UTM N	UTM E	Elevation	Date1	Time Start	Time End
1	0	1	1	a	Northern	2	NAD83	4629782	265973	1804	6/2/2009	2142	100
2	0	2	1	a	Northern	2	NAD83	4623348	357792	1295	########	2130	100
3	0	3	1	b	Northern	5	NAD83	4641354	478722	1874	########	2158	100
3	0	3	1	a	Northern	5	NAD83	4641379	478707	1879	########	2124	100
4	0	4	1	a	Northern	2	NAD83	4546832	337156	1340	########	2120	100
5	0	5	1	a	Northern	4	NAD83	4566637	416223	1266	########	2130	100
6	0	6	1	a	Northern	4	NAD83	4587596	447572	2188	########	2220	100
7	0	7	1	a	Northern	4	NAD83	4545243	463115	2108	7/6/2009	2126	100
8	0	8	1	a	Northern	2	NAD83	4530351	400472	1363	6/3/2009	2130	100
9	0	9	1	a	Northern	5	NAD83	4568442	482105	2131	########	2130	100

File Continued

Net Area	Moonphas	Wstypeclas	WS Length	WS Width	Area	WS Depth	WS Perime	Distlevel cl	Dist timing	Canopy cla	Understory	Geology cla
61.5	4	8	21	2	42	<1	46	1	3	8	2	1
52.5	1	6	18	18	324	<1	72	3	2	1	3	1
97.5	1	4	30	15	450	1	90	2	3	8	3	1
75	2	4	30	15	450	1	90	2	3	8	2	1
67.5	1	9	30	15	450	2	90	1	3	4	2	1
37.5	8	5	18	10	180	1.5	56	1	3	8	2	1
75	4	3	25	60	1500	1	170	3	1	3	3	1
67.5	5	8	30	15	450	2	90	3	1	3	5	1
126.25	4	9	30	30	900	2	120	2	2	1	3	0
97.5	8	4	25	20	500	2	90	3	1	4	3	1

Example SAS code for the statewide presence analysis

```
data anpa;
        infile 'E:anpa.csv'  delimiter=',' firstobs=2;
        input site1     pres Site   Period      Visit$      DWRRegion$
      Ecoregion Datum$ UTMN  UTME  Elevation   Date1$      TimeStart$
      TimeEnd$    NetArea     Moonphase   Wstype      WSLength    WSWidth
      Area  WSDepth$    WSPerimeter Distlevel   Disttiming  Canopy
      Understory  Geology;
```

```
run;
proc print data=anpa;
run;
proc logistic data=anpa descending;
      model54 pres =    ecoregion UTMN Elevation Wstype Canopy          ;

run;
proc logistic data=anpa descending;
      model54 pres =    ecoregion UTMN Elevation Wstype           ;

run;
proc logistic data=anpa descending;
      model54 pres =    ecoregion  Elevation Wstype         ;

run;

proc logistic data=anpa descending;
      model54 pres =    ecoregion         ;

run;
proc logistic data=anpa descending;
      model54 pres =    period            ;

run;
proc logistic data=anpa descending;
      model54 pres =    UTMN        ;

run;
proc logistic data=anpa descending;
      model54 pres =    UTME        ;

run;
proc logistic data=anpa descending;
      model54 pres =    Elevation         ;

run;
proc logistic data=anpa descending;
      model54 pres =    NetArea           ;

run;
proc logistic data=anpa descending;
      model54 pres =          WSLength    ;

run;
proc logistic data=anpa descending;
      model54 pres =          WSWidth;

run;

proc logistic data=anpa descending;
      model54 pres =          Area;

run;
proc logistic data=anpa descending;
      model54 pres =          WSPerimeter;

run;
```

```
proc logistic data=anpa descending;
      model54 pres =          Moonphase;

run;
proc logistic data=anpa descending;
      model54 pres = Wstype         ;

run;
proc logistic data=anpa descending;
      model54 pres =    Disttiming;

run;
proc logistic data=anpa descending;
      model54 pres =          Canopy;

run;
proc logistic data=anpa descending;
      model54 pres =          Understory;

run;
proc logistic data=anpa descending;
      model54 pres =          Geology;

run;
```

Appendix VI. Protocol Sampling Locations. Sampling locations are provided for each sample cell and each period for sample cells. Some sample sites were changed between sampling periods due to the scarcity of water resources. Therefore we recommend that the period three sampling location be used for the next iteration of this protocol.

Acoustic Locations: Gaps in data indicate that no survey was completed (NSC). In the case of Acoustic surveys, this is typically due to equipment or equipment-user error.

Site	Period	Visit	Datum	UTM N	UTM E	Elevation
1	1	a	NAD83	4630285	265978	1829
1	2	a	NAD83	NSC	NSC	NSC
1	3	a	NAD83	4630285	265978	1829
2	1	a	NAD83	4624609	359506	1295
2	2	a	NAD83	4624612	354508	1312
2	3	a	NAD83	4624243	359875	1284
3	1	a	NAD83	4640632	481680	1879
3	1	b	NAD83	NSC	NSC	NSC
3	2	a	NAD83	NSC	NSC	NSC
3	2	b	NAD83	4640662	481697	1883
3	3	a	NAD83	4640662	481697	1883
3	3	b	NAD83	4640662	481697	1883
4	1	a	NAD83	4557088	338182	1534
4	2	b	NAD83	4557090	338173	1529
4	3	c	NAD83	NSC	NSC	NSC
5	1	a	NAD83	NSC	NSC	NSC
5	2	a	NAD83	4566493	461611	1266
5	3	a	NAD83	4566493	461611	1298
6	1	a	NAD83	4587792	448097	2164
6	2	a	NAD83	4587789	448023	2168
6	3	a	NAD83	4587789	448023	2168
7	1	a	NAD83	4545051	463335	2146
7	2	a	NAD83	4545051	463334	2146
7	3	a	NAD83	NSC	NSC	NSC
8	1	a	NAD83	4533967	401396	1364
8	2	a	NAD83	4533994	401463	1292
8	3	a	NAD83	4533994	401463	1292
9	1	a	NAD83	NSC	NSC	NSC
9	1	b	NAD83	4567834	481062	2131
9	2	a	NAD83	4567834	481062	2131
9	2	b	NAD83	4567834	481062	2131
9	3	a	NAD83	4567834	481062	2132
9	3	b	NAD83	NSC	NSC	NSC

10	1	a	NAD83	4521532	469537	1864
10	2	a	NAD83	4521533	469541	1864
10	3	a	NAD83	4521533	469541	1864
11	1	a	NAD83	4534127	535385	2694
11	2	a	NAD83	4534133	535386	2694
11	3	a	NAD83	4534155	536137	2744
12	1	a	NAD83	4494917	584768	2755
12	2	a	NAD83	4494917	584768	2755
12	3	a	NAD83	4494917	584768	2755
13	1	a	NAD83	4494276	630178	1719
13	2	a	NAD83	4494276	630178	1719
13	3	a	NAD83	4494276	630178	1719
14	1	a	NAD83	4525029	612982	2382
14	2	a	NAD83	4525029	612982	2382
14	3	a	NAD83	4525029	612982	2382
15	1	a	NAD83	4537061	660983	2417
15	1	b	NAD83	4537061	660983	2417
15	2	a	NAD83	4537061	660983	2417
15	2	b	NAD83	4537061	660983	2417
15	3	a	NAD83	4537061	660983	2417
15	3	b	NAD83	4537061	660983	2417
16	1	a	NAD83	4484686	503855	2958
16	2	a	NAD83	4484686	503855	2958
16	3	a	NAD83	4484686	503855	2958
17	1	a	NAD83	4482554	539338	2550
17	2	a	NAD83	4482554	539338	2550
17	3	a	NAD83	4482554	539338	2550
18	1	a	NAD83	4454140	484263	2306
18	2	a	NAD83	4454140	484263	2306
18	3	a	NAD83	NSC	NSC	NSC
19	1	a	NAD83	4434325	584179	1576
19	2	a	NAD83	4434325	584179	1576
19	3	a	NAD83	4434325	584179	1576
20	1	a	NAD83	4492721	340629	1399
20	2	a	NAD83	4492733	340616	1402
20	3	a	NAD83	4492733	340616	1402
21	1	a	NAD83	4497788	386292	1298
21	2	a	NAD83	4500506	390270	1299
21	3	a	NAD83	4483973	390899	1655
22	1	a	NAD83	NSC	NSC	NSC
22	2	a	NAD83	NSC	NSC	NSC

22	3	a	NAD83	NSC	NSC	NSC
23	1	a	NAD83	4428748	310076	1318
23	2	a	NAD83	4428748	310092	1461
23	3	a	NAD83	4428753	310089	1439
24	1	a	NAD83	NSC	NSC	NSC
24	2	a	NAD83	4449074	379125	1614
24	3	a	NAD83	NSC	NSC	NSC
25	1	a	NAD83	NSC	NSC	NSC
25	2	a	NAD83	4457340	446531	1558
25	3	a	NAD83	NSC	NSC	NSC
26	1	a	NAD83	4417636	525355	2425
26	2	a	NAD83	4417636	525355	2425
26	3	a	NAD83	4417636	525355	2425
27	1	a	NAD83	4407199	553060	1913
27	2	a	NAD83	4407199	553060	1913
27	3	a	NAD83	4407199	553060	1913
28	1	a	NAD83	4386266	429313	1742
28	2	a	NAD83	4386266	429313	1742
28	3	a	NAD83	NSC	NSC	NSC
29	1	a	NAD83	4375397	478261	2624
29	2	a	NAD83	4375397	478261	2624
29	3	a	NAD83	4375397	478261	2624
30	1	a	NAD83	4347476	519636	1823
30	2	a	NAD83	4347476	519636	1823
30	3	a	NAD83	4347476	519636	1823
31	1	a	NAD83	4340080	473811	2686
31	2	a	NAD83	4340801	473955	2652
31	3	a	NAD83	4340801	473955	2652
32	1	a	NAD83	4370033	622793	1959
32	2	a	NAD83	4370033	622793	1959
32	3	a	NAD83	4370033	627793	1959
33	1	a	NAD83	4415243	647390	1607
33	2	a	NAD83	4415243	647390	1607
33	3	a	NAD83	4415243	647390	1607
34	1	a	NAD83	NSC	NSC	NSC
34	2	a	NAD83	4341303	666082	1410
34	3	a	NAD83	4341303	666082	1410
35	1	a	NAD83	NSC	NSC	NSC
35	2	a	NAD83	4414686	295793	1307
35	3	a	NAD83	NSC	NSC	NSC
36	1	a	NAD83	4366849	252917	1468

36	2	a	NAD83	4366849	252917	1468
36	3	a	NAD83	4366849	252917	1468
37	1	a	NAD83	4368223	346661	1394
37	2	a	NAD83	4368223	346661	1394
37	3	a	NAD83	NSC	NSC	NSC
38	1	a	NAD83	4337474	336368	1390
38	2	a	NAD83	4337474	336368	1390
38	3	a	NAD83	NSC	NSC	NSC
39	1	a	NAD83	NSC	NSC	NSC
39	2	a	NAD83	4274241	242478	2170
39	3	a	NAD83	4274241	242478	2170
40	1	a	NAD83	4357102	393612	1951
40	2	a	NAD83	4356711	391844	1951
40	3	a	NAD83	NSC	NSC	NSC
41	1	a	NAD83	4294167	441660	2542
41	2	a	NAD83	4295436	444295	2635
41	3	a	NAD83	4295436	444295	2635
42	1	a	NAD83	4312093	578748	1300
42	2	a	NAD83	4312093	578748	1300
42	3	a	NAD83	4312093	578748	1300
43	1	a	NAD83	4262148	459229	2870
43	2	a	NAD83	4264218	459229	2870
43	3	a	NAD83	4264218	459229	2870
44	1	a	NAD83	4247217	532482	1287
44	2	a	NAD83	4247217	532482	1287
44	3	a	NAD83	4247217	532482	1287
45	1	a	NAD83	4246564	643838	1888
45	2	a	NAD83	4242529	645323	1916
45	3	a	NAD83	4242529	645323	1916
46	1	a	NAD83	4246073	555424	1676
46	2	a	NAD83	4246073	555424	1676
46	3	a	NAD83	4246073	555424	1676
47	1	a	NAD83	4180821	530765	1609
47	2	a	NAD83	4180821	530765	1609
47	3	a	NAD83	4180821	530765	1609
48	1	a	NAD83	4163347	576670	1639
48	2	a	NAD83	4162122	577302	1662
48	3	a	NAD83	4162122	577302	1662
49	1	a	NAD83	4203808	662904	2061
49	2	a	NAD83	4203808	662904	2061
49	3	a	NAD83	4203808	662904	2061

50	1	a	NAD83	4254526	295356	1594
50	2	a	NAD83	4250380	294771	1680
50	3	a	NAD83	NSC	NSC	NSC
51	1	a	NAD83	4276041	417161	2913
51	2	a	NAD83	4276041	417161	2913
51	3	a	NAD83	4276573	416467	1859
52	1	a	NAD83	4231325	334614	1634
52	2	a	NAD83	4231325	334614	1634
52	3	a	NAD83	NSC	NSC	NSC
53	1	a	NAD83	4209312	255516	1846
53	2	a	NAD83	4209312	255516	1846
53	3	a	NAD83	4212406	266014	1843
54	1	a	NAD83	4183312	353636	2751
54	2	a	NAD83	4183312	353636	2751
54	3	a	NAD83	4183312	353636	2751
55	1	a	NAD83	4201843	431249	2096
55	2	a	NAD83	4201111	435939	3025
55	3	a	NAD83	4201111	435939	3025
56	1	a	NAD83	4158270	405803	1758
56	2	a	NAD83	4158270	405803	1758
56	3	a	NAD83	4158270	405803	1758
57	1	a	NAD83	4116244	602738	1259
57	2	a	NAD83	4116244	602738	1259
57	3	a	NAD83	4116244	602738	1259
58	1	a	NAD83	4154747	307149	1716
58	2	a	NAD83	4154747	307149	1716
58	3	a	NAD83	4154747	307149	1716
59	1	a	NAD83	4139446	282399	2182
59	2	a	NAD83	4140048	280696	1852
59	3	a	NAD83	4140048	280696	1852
60	1	a	NAD83	4120930	287106	Unk
60	2	a	NAD83	4120930	287106	Unk
60	3	a	NAD83	4120930	287106	Unk
61	1	a	NAD83	4112273	363194	1588
61	2	a	NAD83	4112273	363194	1588
61	3	a	NAD83	4112273	363194	1588
62	1	a	NAD83	4107240	240573	1158
62	1	b	NAD83	4107240	240573	1158
62	2	a	NAD83	4107240	240573	1158
62	2	b	NAD83	4107240	240573	1158
62	3	a	NAD83	4107240	240573	1158

62	3	b	NAD83	4109641	241248	1319
63	1	a	NAD83	4106648	255866	1142
63	1	b	NAD83	4106648	255866	1142
63	2	a	NAD83	4106648	255866	1142
63	2	b	NAD83	4098450	285255	878
63	3	a	NAD83	4098400	285464	Unk
63	3	b	NAD83	4098400	285464	Unk
64	Removed from sample due to lack of water.					
64						
64						
65	1	a	NAD83	4104355	648789	1656
65	2	a	NAD83	4104355	648789	1656
65	3	a	NAD83	4104355	648789	1656

Capture Locations: Gaps in data indicate that no survey was completed (NSC).

Site	Period	Datum	UTM N	UTM E	Elevation
1	1	NAD83	4629782	265973	1804
1	2	NAD83	4629782	265955	1803
1	3	NAD83	4629782	265973	1804
2	1	NAD83	4623348	357792	1295
2	2	NAD83	4623355	357787	1293
2	3	NAD83	4623355	357787	1293
3	1	NAD83	4641379	478707	1879
3	1	NAD83	4641354	478722	1874
3	2	NAD83	4641382	478708	1892
3	2	NAD83	4641384	478709	1873
3	3	NAD83	4641384	478709	1873
3	3	NAD83	4641384	478709	1873
4	1	NAD83	4546832	337156	1340
4	2	NAD83	NSC	NSC	NSC
4	3	NAD83	NSC	NSC	NSC
5	1	NAD83	4566637	416223	1266
5	2	NAD83	4566635	416199	1266
5	3	NAD83	4566635	416199	1266
6	1	NAD83	4587596	447572	2188
6	2	NAD83	4587633	447569	2187
6	3	NAD83	4587639	447569	2187
7	1	NAD83	4545243	463115	2108
7	2	NAD83	4545243	463115	2108
7	3	NAD83	4545243	463115	2108

8	1	NAD83	4530351	400472	1363
8	2	NAD83	4530355	400446	1363
8	3	NAD83	4530336	400463	1355
9	1	NAD83	4568442	482105	2131
9	1	NAD83	4567957	481172	2131
9	2	NAD83	4568461	482119	2131
9	2	NAD83	4568441	482105	2134
9	3	NAD83	4568442	482105	2131
9	3	NAD83	4568454	482100	2134
10	1	NAD83	4570998	470315	1921
10	2	NAD83	4570998	470315	1921
10	3	NAD83	4570998	470315	1921
11	1	NAD83	4534152	536135	2744
11	2	NAD83	4534155	536137	2744
11	3	NAD83	4534346	535503	2694
12	1	NAD83	4492907	585057	2522
12	2	NAD83	4492907	585057	2522
12	3	NAD83	4492907	585057	2522
13	1	NAD83	4492882	629824	1791
13	2	NAD83	4492882	629824	1791
13	3	NAD83	4492882	629824	1791
14	1	NAD83	4527263	615062	2354
14	2	NAD83	4527263	615062	2354
14	3	NAD83	4527263	615062	2354
15	1	NAD83	4540499	663099	2575
15	1	NAD83	4540499	663099	2575
15	2	NAD83	4540497	663102	2574
15	2	NAD83	4540497	663102	2574
15	3	NAD83	4540497	663102	2574
15	3	NAD83	4540499	663099	2575
16	1	NAD83	4485595	504457	2910
16	2	NAD83	4485595	504457	2910
16	3	NAD83	4485595	504457	2910
17	1	NAD83	4484337	540198	2824
17	2	NAD83	4484337	540198	2824
17	3	NAD83	4484337	540198	2824
18	1	NAD83	4452748	482311	2376
18	2	NAD83	4452748	482311	2376
18	3	NAD83	4452748	482311	2376
19	1	NAD83	4435033	584100	1572
19	2	NAD83	4435033	584100	1572

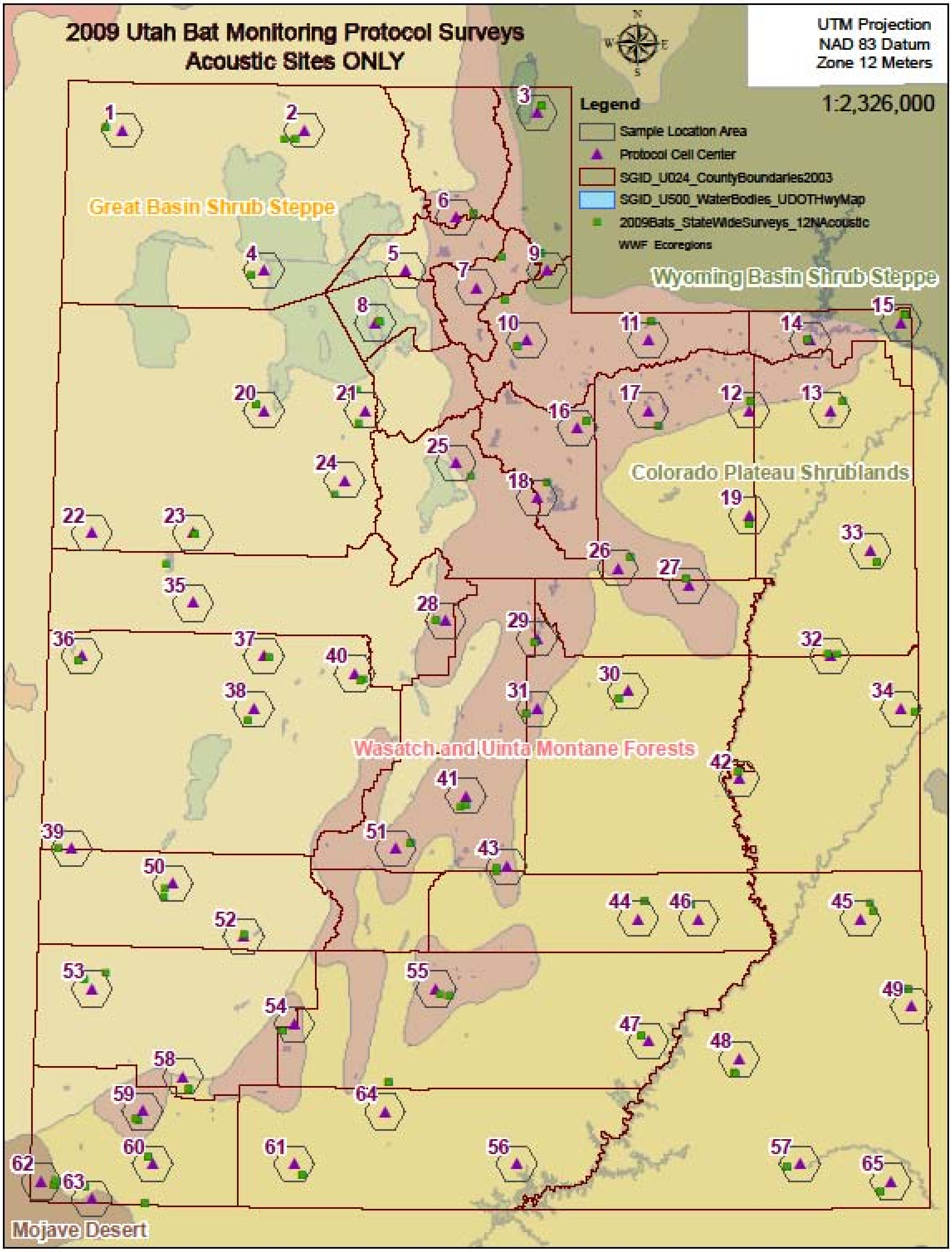
19	3	NAD83	4435033	584100	1572
20	1	NAD83	4492269	339934	1432
20	2	NAD83	4492269	339934	1432
20	3	NAD83	4492269	339934	1432
21	1	NAD83	4497788	386292	1298
21	2	NAD83	4497788	386292	1298
21	3	NAD83	4483973	390899	1655
22	1	Not recorded	4428918	250484	2004
22	2	Not recorded	4428918	250484	2004
22	3	Not recorded	4428918	250484	2004
23	1	NAD83	4429952	308566	1313
23	2	NAD83	4429952	308566	1313
23	3	NAD83	4429952	308571	1316
24	1	NAD83	4449906	379892	2196
24	2	NAD83	4449898	379906	2196
24	3	NAD83	4449895	379900	2196
25	1	NAD83	4455101	444627	2169
25	2	NAD83	4455101	444627	2169
25	3	NAD83	4455101	444627	2169
26	1	NAD83	4418625	520503	2482
26	2	NAD83	4418625	520529	2479
26	3	NAD83	4418625	520503	2482
27	1	NAD83	4408139	550048	1965
27	2	NAD83	4408139	550048	1965
27	3	NAD83	4408139	550048	1965
28	1	NAD83	4377913	429163	1692
28	2	NAD83	4378100	429092	1692
28	3	NAD83	4378100	429092	1692
29	1	NAD83	4374448	478370	2689
29	2	NAD83	4374448	478370	2689
29	3	NAD83	4374448	478370	2689
30	1	NAD83	4352171	524860	1763
30	2	NAD83	4351551	526033	1760
30	3	NAD83	4351551	526033	1760
31	1	NAD83	4340801	473955	2652
31	2	NAD83	4340080	473811	2686
31	3	NAD83	4340080	473811	2686
32	1	NAD83	4375320	622280	2206
32	2	NAD83	4370401	622566	1978
32	3	NAD83	4370401	622566	1978
33	1	NAD83	4416768	647663	1589

33	2	NAD83	4416768	647663	1589
33	3	NAD83	4416768	647663	1589
34	1	NAD83	4341816	665893	1416
34	2	NAD83	4341816	665893	1416
34	3	NAD83	4341816	665893	1416
35	1	NAD83	4413578	295110	1340
35	2	NAD83	4413578	295110	1340
35	3	NAD83	4413578	295110	1340
36	1	NAD83	4365259	253548	1471
36	2	NAD83	4365259	253548	1471
36	3	NAD83	4365456	253456	1471
37	1	NAD83	4366527	348147	1395
37	2	NAD83	4366527	348147	1395
37	3	NAD83	4366527	348147	1395
38	1	NAD83	4334555	339839	1389
38	2	NAD83	4334555	339839	1389
38	3	NAD83	4334555	339839	1389
39	1	NAD83	4276579	246278	2027
39	2	NAD83	4276579	246278	2027
39	3	NAD83	4276579	246278	2027
40	1	NAD83	4356509	391905	1898
40	2	NAD83	4356711	391844	1898
40	3	NAD83	4356711	391844	1898
41	1	NAD83	4293717	440696	2586
41	2	NAD83	4294167	441660	2542
41	3	NAD83	4294167	441660	2542
42	1	NAD83	4309403	575418	1231
42	2	NAD83	4309403	575418	1231
42	3	NAD83	4309403	575418	1232
43	1	NAD83	4259408	461865	2687
43	2	NAD83	4259408	461865	2687
43	3	NAD83	4259408	461865	2687
44	1	NAD83	4247611	532876	1283
44	2	NAD83	4247611	532876	1283
44	3	NAD83	4247611	532876	1283
45	1	NAD83	4246564	643838	1888
45	2	NAD83	4246564	643838	1888
45	3	NAD83	4246564	643838	1888
46	1	NAD83	4245933	554775	1639
46	2	NAD83	4245933	554775	1639
46	3	NAD83	4245933	554775	1639

47	1	NAD83	4173789	530169	1439
47	2	NAD83	4173789	530169	1439
47	3	NAD83	4173789	530169	1439
48	1	NAD83	4163347	576670	1639
48	2	NAD83	4163347	576670	1639
48	3	NAD83	4163347	576670	1639
49	1	NAD83	4204282	662243	2046
49	2	NAD83	4204282	662243	2046
49	3	NAD83	4204282	662243	2046
50	1	NAD83	4258669	305102	1897
50	2	NAD83	4250380	294771	1680
50	3	NAD83	4250380	294771	1680
51	1	NAD83	4277476	416099	2881
51	2	NAD83	4277476	416099	2881
51	3	NAD83	4276573	416467	1859
52	1	NAD83	4236744	334122	1863
52	2	NAD83	4236744	334122	1863
52	3	NAD83	4236744	334122	1863
53	1	NAD83	4206900	254616	1902
53	2	NAD83	4206900	254616	1902
53	3	NAD83	4212406	266014	1843
54	1	NAD83	4184666	353417	2848
54	2	NAD83	4184666	353417	2848
54	3	NAD83	4184666	353417	2848
55	1	NAD83	4201843	431249	2096
55	2	NAD83	4201111	435939	3025
55	3	NAD83	4201111	435939	3025
56	1	NAD83	4158270	405803	1758
56	2	NAD83	4158270	405803	1758
56	3	NAD83	4158270	405803	1758
57	1	NAD83	4115877	603129	1257
57	2	NAD83	4115877	603129	1257
57	3	NAD83	4115877	603129	1257
58	1	NAD83	4156987	307974	1724
58	2	NAD83	4156987	307974	1724
58	3	NAD83	4156987	307974	1724
59	1	NAD83	4139656	281124	1935
59	2	NAD83	4130956	281124	1935
59	3	NAD83	4130956	281124	1935
60	1	NAD83	4122124	286805	976
60	2	NAD83	4122124	286805	976

60	3	NAD83	4122124	286805	976
61	1	NAD83	4112091	363288	1574
61	2	NAD83	4112091	363288	1574
61	3	NAD83	4112091	363288	1574
62	1	NAD83	4109641	241248	1319
62	1	NAD83	4109641	241248	1319
62	2	NAD83	4109641	241248	1319
62	2	NAD83	4109641	241248	1319
62	3	NAD83	4109641	241248	1319
62	3	NAD83	4109641	241248	1319
63	1	NAD83	4104995	260826	883
63	1	NAD83	4104995	260826	883
63	2	NAD83	4104995	260826	883
63	2	NAD83	4098450	285255	878
63	3	NAD83	4104995	260826	883
63	3	NAD83	4104995	260826	883
64	Removed from sample due to lack of water				
64					
64					
65	1	NAD83	4104394	649535	1672
65	2	NAD83	4104394	649535	1672
65	3	NAD83	4102377	649615	1619

Appendix VII. Sample cell locations across ecoregion and acoustic survey sites.



Appendix VIII. Protocol Data Sheet Data Dictionary (Table 4).

Table 4. Explanations of field for the covariate data sheet (Tables 2 and 3)

Site Location

Ecoregion

World Wildlife Fund designated ecoregions (Colorado Plateau shrublands, Great Basin sagebrush steppe, Mojave Desert and the combined Wasatch and Uinta montane forest and Wyoming Basin shrub steppe).

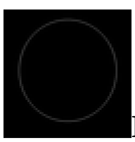
Site #

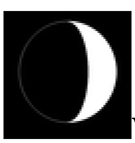
A unique identifier between 1 and 20 within each ecoregion.

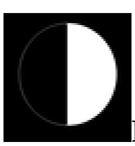
UTM

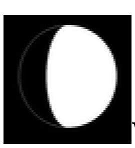
The Universal Transverse Mercator (**UTM**) coordinate system, X and Y values.

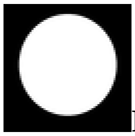
Moon Phase

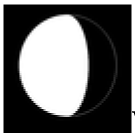
**New Moon** - The Moon's unilluminated side is facing the Earth. The Moon is not visible (except during a solar eclipse).

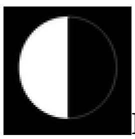
**Waxing Crescent** - The Moon appears to be partly but less than one-half illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.

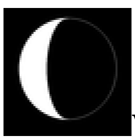
**First Quarter** - One-half of the Moon appears to be illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.

**Waxing Gibbous** - The Moon appears to be more than one-half but not fully illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is increasing.

**Full Moon** - The Moon's illuminated side is facing the Earth. The Moon appears to be completely illuminated by direct sunlight.

**Waning Gibbous** - The Moon appears to be more than one-half but not fully illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.

**Last Quarter** - One-half of the Moon appears to be illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.

**Waning Crescent** - The Moon appears to be partly but less than one-half illuminated by direct sunlight. The fraction of the Moon's disk that is illuminated is decreasing.

Elevation

Elevation in meters.

Netting Site Description

Type

1) **Earthen Tank**: Manmade pond with water available at ground level only.
2) **Guzzler**: State or federally maintained wildlife guzzler, water at ground level only.
3) **Trough**: Traditional rectangular cattle or sheep watering troughs, accessible water is above ground level.
4) **Tank**: Cattle or sheep round tank, accessible water is above ground level.
5) **Stream**: Low order flowing water source
6) **Oxbow**: Slow flowing water in a higher order water source
7) **Backwater**; Standing water disconnected from adjacent flowing water
8) **Misc**.: Any other type of water site, be specific.

Water Source

This is a broader description of the sampled water source based on the **length** and **width** at the broadest point, **depth** at the center, and a measured **perimeter**.

Obstruction

Obstruction is the presence of any obstruction on or near the water surface which may affect bat watering behavior. **Vegetation** obstructions include moss/algae on water surface and any standing vegetation in or above the water site. A second category of obstruction is **wire** or associated man-made articles across the water surface. Estimate the percentage cover for each obstruction category

Other Taxa

All other organism observed using the area should be recorded (common name and detection method) and categorized as a mammal, amphibian, reptile or bird. List all species sign observed with 100 m of the net site during the sampling periods.

Human Disturbance

Human disturbance describes the level and timing of human activity near the survey site. The level of disturbance has three classes; high, medium and low. Urban and developed areas and the like should be categorized as **high** disturbance. Non-developed wildlands with high human recreational or management based impacts should be categorized as **medium**. Sites with **low** disturbance levels are those that retain some native vegetation adjacent to the water source and a low impact of grazing practices or recreational activities. The timing of human disturbance also has three classes; continuous, intermittent and rare.

Local Habitat Description

Land cover

Land cover refers to the Southwest Regional Gap Analysis Project (ReGAP) land cover types (Appendix II). Each site may fall into several land cover types.

Land form

Land form refers to the Southwest Regional Gap Analysis Project (ReGAP) land form types (Appendix II). Each site may fall into several land form types.

Canopy

Canopy refers to the top most layer of vegetation dominant within the local habitat. The **forest** canopy type refers to deciduous or coniferous forests such as cottonwood or spruce fir. **Woodland** canopy types references pinyon-juniper woodlands. **Mountain brush** canopy type is characterizied by gambel oak, mountain mahogany, maple or associated brush. **Brush canopy** refers to sagebrush or creosote shrubland canopy cover. **Grass** refers to an overstory or monoculture of grass.

Understory

Mountain brush, brush and grass are also used as understory types. Two addition types: **Invasive forb** and **bare soil** dominated understory.

Soil type

Soil type refers to the Natural Resource Conservation Service soil survey for the site

Geology

Geology refers to the dominant rock type adjacent to the survey site.

Adjacent potential roosts

Any bat roosting habitat within 10 km of the survey site which may provide bat roosting habitat. **Crevice** habitat refers to any cracks wider than 2cm, **mine** habitat refers to any apparent underground mining features, **cave** habitat refers to any natural underground features, **foliage** habitat is the presence of broad leaved and conifer roosting opportunities, **tree** roosts refers to the nearest standing dead tree (snag), **bridge** habitat refers to the nearest roadway and culvert bridge and **human structures** refers to any other manmade potential roosting sites. The **distance** to each of the potential roosts described above should be estimated in miles.

Appendix IX. Disinfection Protocol for Bat Field Research/Monitoring, U.S. Fish and Wildlife Service (June 2009).

Disinfection Protocol for Bat Field Research/Monitoring
U.S. Fish and Wildlife Service
June 2009

To minimize the potential for transmission of white-nose syndrome (WNS) while handling bats (both between handler and bats, between bats, and between handler and environment), these procedures are highly recommended. To date, WNS has been discovered in the northeastern US and mid-Atlantic states[1]. The U.S. Fish and Wildlife Service (USFWS) advises implementation of equipment decontamination protocols to reduce the risk of unintentional, human-assisted spread of WNS. In addition, we recommend that similar guidelines be used any time people handle wildlife to minimize potential disease-related impacts to wildlife and people. ***Please note that individual states/agencies may have additional permitting requirements above and beyond these general procedures.*** Additional restrictions apply for individuals conducting research in USFWS Region 3 - Ohio, Indiana, Illinois, Missouri, Iowa, Wisconsin, Michigan and Minnesota - either under a federal permit or Section 6 authorities as these states are currently unaffected by WNS. The requirements for Region 3 are posted at:
http://www.fws.gov/midwest/Endangered/mammals/BatDisinfectionProtocol.html.
These guidelines may be revised upon review of new information.

Any equipment that comes in contact with bats, individuals handling bats, or the environments where bats occur has the potential to be a vector for the spread of WNS. Examples include mist nets, harp traps, bat bags, wing biopsy punches, weighing tubes, rulers, clothing, and gloves.

Decontamination recommendations target the fungus *Geomyces* sp., which to date has been the most consistent pathogen recovered from bats exhibiting signs of WNS. Fortunately, many of the disinfectants/techniques tested for efficacy against the fungus are also suitable to kill other bacterial or viral agents should another causative agent of this disease be identified.

CAUTION: Disinfectant efficacy is based on application to hard, nonporous surfaces and the ability to prevent the regrowth of *Geomyces* sp. on artificial culture media. Tests are currently being conducted on porous fiber materials such as ropes and harnesses to determine disinfectant efficacy to kill the fungus on these substrates and their effects on gear integrity. The repeated use of disinfecting agents may compromise the effective use of vertical equipment; therefore, this equipment should be dedicated to one cave or not used at all.

Although a site may be affected with WNS, it should not be assumed that all individual bats within the site are infected or will become infected, and thus, care should be taken not to cross-contaminate specimens by lax handling methods. This is especially true if samples are to be submitted for diagnostic purposes.

Decontaminate all clothing, footwear, and gear prior to departing for a bat netting or cave outing if you did not decontaminate these items after last netting activity or exiting a cave. In affected and unaffected states, we ask that you not take gear into a cave if that gear cannot be thoroughly decontaminated or disposed of (i.e. if harnesses, ropes, or webbing cannot be decontaminated, we advise that you not enter caves or parts of caves requiring use of this gear).

In addition, only bring essential equipment used for bat netting and processing to a site, other non-essential items should be left home as they may contribute to spreading the fungus.

PROCEDURES:

Vehicles:

Do not work on live bats in vehicles. Vehicles used to transport equipment may harbor spores. Do all processing on vehicle hood or on a table away from the vehicle. The tailgate is not preferred since it is likely near netting equipment. A drawstring garbage bag should be placed at each site outside the field vehicle each night so all contaminated bags, gloves, wipes, etc., are contained. Dead bats should be placed in a sealed plastic container and placed inside a second bag or container handled only with clean gloves. This outer packaging layer is considered clean and uncontaminated and safe to transport inside the vehicle (preferably contained within a clean cooler).

Submersible Gear (i.e. clothing and soft-sided equipment):

- For clothing – Wash all clothing and any appropriate equipment in washing machine using the hottest cycle possible for material and conventional detergents. Laboratory testing has found Woolite® fabric wash to be the best surfactant for clothing. Rinse thoroughly, and then follow by soaking with sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 9 parts water in a tub or plastic container. Soak for 10 minutes, then rinse and air dry. If field projects necessitate extended efforts at remote locations, with no travel to new or additional sites, and daily washing or decontamination is not possible, then at the least, wash/decontaminate all clothing and other soft-sided equipment that has had direct contact with bats using the recommended procedures specified above.

- For other submersible gear (i.e. bags, gloves, nets, etc.) – Disinfect any equipment that can be submersed in a solution with an appropriate and compatible disinfectant such as sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 9 parts water in a tub or plastic container or $\geq$ 0.3% concentration of quaternary ammonium compounds (i.e. Sparquat 256, Lysol® All-purpose Professional Cleaner, or the antibacterial form of Formula 409®). Keep submersed for 10 minutes, then rinse and air dry.

Nets:

- Use separate sets between states known to be affected by WNS[1] and states currently unaffected. Realizing that some WNS affected states contain both affected and unaffected sites, under no circumstances should nets that have been used in an affected site be used in an unaffected site. Contact your state wildlife agency for updated information regarding WNS affected sites by visiting the following webpage http://www.fws.gov/offices/statelinks.html.

Bats should be kept in breathable holding bags rather than holding cages. To avoid cross-contamination of samples, it is imperative to keep bats separated using holding bags that are kept as clean as possible. Non-disposable holding bags should be used only once per night of field work and should be washed and decontaminated (following procedures above) and dried between nights of use. Disposable paper bags are also a convenient option for holding bats temporarily. Only one bat should be in a given bag, and that bag should not be reused for a new bat.

Disposable exam gloves should be worn over handling gloves and changed in between handling each bat. Disposable gloves should be one size larger than the handling gloves. Smooth leather gloves may be wiped down with a disinfectant (i.e. Purell®, Lysol® disinfecting wipes or alcohol wipes) in between handling bats. If only using leather gloves, each handler should have several sets of gloves to interchange in between handling bats. This allows time to effectively kill the fungus and for the disinfectant to completely dry. After each night of netting, remove heavy soil deposits from surface of bags and gloves, soak in an appropriate disinfectant, then dry completely.

For situations when gloves may hinder field work (i.e. transmitter attachment) and bats come in contact with bare hands, apply hand sanitizer with alcohol (i.e. Purell®) after handling each bat. Make sure it dries completely before handling the next bat.

<u>**Non-submersible Gear** (i.e. hard-sided equipment):</u>

- <u>For non-submersible gear</u> (i.e. bat processing equipment, mist net poles, harp trap frames and legs, folding chairs, etc.) – Disinfect any equipment that cannot be submersed by applying an appropriate and compatible disinfectant to the outside surface by using ≥ 0.3% concentration of quaternary ammonium compounds such as Sparquat 256, Lysol® All-purpose Professional Cleaner or the antibacterial form of Formula 409®, or use sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 9 parts water. Keep on surface for 10 minutes, then rinse and air dry.

- <u>For boots</u> – Boots need to be fully scrubbed and rinsed so that all soil and organic material is removed. The entire rubber and leather boots, including soles and leather uppers, can then be disinfected with an appropriate disinfectant such as ≥ 0.3% concentration of quaternary ammonium compounds (i.e. Sparquat 256, Lysol® All-purpose Professional Cleaner or the antibacterial form of Formula 409®) or sodium hypochlorite bleach (i.e. household bleach) solution diluted to 1 part bleach to 9 parts water. Keep on surface for 10 minutes, then rinse and air dry.

Use one of the disinfecting agents listed above to sanitize all equipment that comes into contact with a bat's body, including light boxes, banding pliers, rulers, calipers, scale, etc. Any instrument coming into direct contact with bat skin should be rinsed free of chemical disinfectant using clean water or physiologic (0.9%) saline. Clean items after handling each bat. If using containers to weigh bats, separate containers used to weigh tree bats from cave bats, do not place tree bats in the same container previously used for a cave bat. Containers used to weigh bats (film canisters, baggies, cardboard rolls) should be disinfected in between handling each bat.

Paper lunch bags can be used for holding and weighing individual bats, and can be immediately discarded after each use. Plastic baggies can also be used to line weighing containers, and bats can even be held in unsealed plastic bags during forearm measurements, reducing contact with wing rulers or calipers. Discard used bags after each bat. Disinfect gloves or discard disposable gloves after handling each bat.

Harp traps:

- Use separate traps between states known to be affected by WNS[1] and states currently unaffected. Realizing that some WNS affected states contain both affected and unaffected sites, under no circumstances should traps that have been used in an affected site be used in an unaffected site. Contact your state wildlife agency for updated information regarding WNS affected sites by visiting the following webpage http://www.fws.gov/offices/statelinks.html.

- In both affected[1] and unaffected states, we recommend that traps be cleaned nightly after use to remove any dirt/debris from wires/lines and bags. Following cleaning, all surfaces should be sprayed with one of the disinfecting agents listed above. Swab the bag with disinfectant and allow to dry completely (preferably in the sun) prior to the next use. Do not use equipment in an unaffected site following use in an affected site.

- We recognize that when working at a maternity colony using harp traps where regular bat to bat contact occurs, that some of the recommended decontamination procedures may not be practical. Therefore, we recommend checking the catch bag more frequently in order to reduce the amount of time that bats are in contact with each other and the bag. To reduce cross-contamination, the catch bag may be lined with a sheet of plastic and replaced with new plastic periodically or wiped down with one of the disinfecting agents above. Disposable gloves should be worn over handling gloves and swapped out regularly throughout the night, or frequently disinfected using Lysol® disinfecting wipes or alcohol wipes.

Cameras, Computers, and Other Electronic Equipment:

If possible, do not bring electronic equipment to a netting site. If practical, cameras and other similar equipment that must be brought to a site may be wrapped in plastic wrap where only the lens is left unwrapped to allow for photos to be taken. The plastic wrap can then be decontaminated by using Lysol® disinfecting wipes and discarded after use. If using plastic wrap is not practical, alcohol wipes or Lysol® disinfecting wipes can be applied directly on surfaces.

Wing Biopsies:

If collecting wing biopsies for any approved research studies on Federally threatened or endangered bats, use a new (unused) sterile punch for each bat. For other bats, punches may be reused, but only if they are still sharpenough to make clean punches. If there is evidence of fungal infection on any individual, use new punches. Be sure to completely sterilize recycled punches between bats by dipping the cutting end in alcohol. Pass the cutting end through a flame 3-4 times, and then allow the flaming punch to naturally extinguish, and cool completely. The

cutting board must also be disinfected between processing individual bats using one of the agents detailed above. Disposable, stiff cardboard squares (1 per individual) can be used as an alternate support for biopsy.

Notification of Signs of WNS

As a reminder, the white fungus is only one of the signs of WNS. We do not expect to find bats with fungus on them during the summer or fall, but bats could still be infected during these seasons. Other possible signs of WNS may be damage to wings and tail membranes in the form of lesions, flakiness or dehydrated skin, discolored spots/scarring, multiple holes, or tears to leading edge of membranes. We encourage the use of Reichard's Wing Damage Index (link below) for assessing bats. Please photograph any damage you observe and report it to the nearest U.S. Fish and Wildlife Service Field Office and your state agency that issued your bat handling permit within 24 hours.
http://www.fws.gov/northeast/PDF/Reichard_Scarring%20index%20bat%20wings.pdf

Important Note: These protocols are posted on the U.S. Fish and Wildlife Service Northeast Region website at: http://www.fws.gov/northeast/white_nose.html. We recommend that you visit the site at least once every six weeks to ensure that you are using the most recent protocol in your permitted activities.

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[1] **WNS Affected States:** Connecticut, Massachusetts, New York, Pennsylvania, Vermont, New Hampshire, New Jersey, West Virginia, and Virginia

Note: The listed WNS affected and adjacent states are current as of 6-9-09, please visit http://www.fws.gov/northeast/white_nose.html for the most updated information.

What is known about *Geomyces* sp. viability:

- The fungus survives exposure to mammalian body temperature (38°C/100°F) for at least 3 days, but does not remain viable after 8 days (W. Stone, NYSDEC, pers. communication 4/14/09).

- The fungus survives exposure to temperature (30°C/86°F) for at least 15 days. (W. Stone, NYSDEC, pers. communication 4/14/09).

- Short-term incubation of fungus at higher temperatures reduces the number of conidia present and alters the morphology of the hyphae which may not inhibit growth once returned to colder temperatures (W. Stone, NYSDEC and D. Blehert, USGS NWHC, pers. communication 4/14/09).

- Clothes dryer heat treatment (49°C/ 120°F) alone increases fungal spore germination and does not kill the fungus (H. Barton, NKU, pers. communication 4/22/09).

What kills the *Geomyces* sp. fungus:

Method	Conditions	Kill Time	Source	Cautions*
Disinfectant				
5.25% Chlorine bleach	10% bath solution (1 part bleach: 9 parts water)	10 min	Over the counter	Inactivated by organic material, detergents; corrosive to metals; produces toxic gas if combined with ammonia; skin irritant
Lysol® Professional Antibacterial All Purpose Cleaner	1:128 bath solution (1 oz per 1 gal water)_	10 min	Janitorial supply	Corrosive; skin & eye irritant
	1:64 bath solution (2 oz per 1 gal water)	5 min		
Sparquat 256	½ oz per 1 gal water	10 min	www.chemsearch.com	May require license to obtain; requires special disposal methods
Promicidal™	1:128 bath solution (1 oz per 1 gal water)	10 min	www.chemsearch.com	May require license to obtain; requires special disposal methods
Grenadier™	1:64 bath solution (2 oz per 1 gal water)	10 min	www.chemsearch.com	May require license to obtain; requires hazardous waste disposal methods
	1:32 bath solution (4 oz per 1 gal water)	5 min		
Formula 409®	At least 0.3% concentration	10 min	Over the counter	
Woolite®	Refer to product label		Over the counter	
Dawn® antibacterial hand soap	Refer to product label		Over the counter	
Purell®	Refer to product label		Over the counter	
Lysol® disinfecting wipes	Refer to product label		Over the counter	
70%-95% ethanol	Undiluted bath	2 min	Lab supply distributor	Flammable, skin irritant
Temperature				
Dry heat	110°F/ 43°C	12 hr	Oven, incubators	
	165°F/ 74°C	15 min		
	175°F/ 79°C	5 min		
	180°F/ 82°C	5 min		
Sterilization				
Steam autoclave	121°C; 15 psi	15 min	Laboratory or hospital settings	
Gas sterilization	Ethylene oxide	16-18 hr	Only available at hospitals	
Flame sterilization	Alcohol & open flame	15-20 sec		Fire hazard; burn injuries

* Effects of different decontamination methods on the integrity of caving equipment are currently being tested.